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ORIGINAL ARTICLES.

I.—Fossil Mammalia from Egypt.

By Chas. W. Andrews, B.Sc., F.G.S., British Museum (Nat. Hist.).

(PLATE XXIII.)

A CONSIDERABLE collection of mammalian bones obtained by the officers of the Egyptian Geological Survey, and sent to England by Captain H. Lyons for determination, proves to contain a number of specimens of great interest. The remains unfortunately are, for the most part, very fragmentary and in many cases quite indeterminable, but they are still sufficient to indicate the existence in Northern Egypt of several distinct mammalian faunas, the oldest being of Lower Miocene age, the most recent probably late Pleistocene and including species now living in the Nile Valley. As far as I am aware, the occurrence of Lower Miocene land mammals in Africa has not been recorded before, and it is to be hoped that continued search may lead to further discoveries, which cannot fail to throw much light on some obscure questions of geographical distribution.

In describing the specimens received hitherto it will be convenient to begin with the older forms and then pass on to the later.

Mammals from the Lower Miocene (Burdighalien).

The principal locality in which mammalian remains of this age have been obtained is Moghara, which lies in the desert rather more than a hundred miles nearly due west of Cairo. Most of the specimens were collected by Dr. M. Blanckenhorn, who, in a letter accompanying the specimens, has given a brief description of the deposits in which they were found. From this it appears that the beds form a series of alternating marine, fluviatile, and lacustrine deposits, some 200 metres thick; there is much sand and gravel, containing great silicified tree trunks as well as the remains of mammals and reptiles. Above or intercalated in these deposits, there is a bed of ochreous sandy marl containing characteristic Lower Miocene Echinoids and Molluscs. There are also some beds of *Hydrobia* limestone.

The occurrence of such deposits indicates the proximity of the shore-line of the Mediterranean as it existed previous to the Helvetian overlap. Rocks of the same character and containing a similar mammalian fauna occur in France (Sables de l'Orléanais), in Switzerland, and near Eggenburg in Austria, and may be regarded as contemporaneous deposits near the northern shore of the same sea.

Brachyodus africanus, sp.n.

The most important of the specimens from this horizon is an imperfect right ramus of the mandible (No. 2,849) of a large anthracotheroid ungulate (see Plate XXIII). The region in front of pm. 3 is wanting, and posteriorly the bone has been broken across 3 or 4 cm. behind the last molar, so that the articulation and angle are lost, and only the base of the coronoid process is preserved; it cannot be determined whether the angle was produced downward into a flange projecting below the level of the ramus, or not. The molars and last premolar are in an excellent state of preservation, but pm. 3 is represented only by its fangs implanted in their alveoli. The condition both of this specimen and of others from the same locality is such as to indicate that careful excavations would probably lead to the discovery of very well-preserved mammalian remains. The mandible in question was collected by Dr. Blanckenhorn, who pointed out that it probably indicated a new species of Depéret's genus *Brachyodus*, for which he proposed the name *B. africanus*, a suggestion which is here adopted. The genus *Brachyodus* was founded by Depéret[1] for the reception of certain species of anthracotheroid ungulates which had hitherto been referred to *Anthracotherium*[2] or *Ancodus*.[3] He takes *Anthracotherium onoideum* of Gervais[2] as the type of the genus, and describes a well-preserved mandible, together with some upper teeth and a calcaneum of this species from the Lower Miocene of Eggenburg.

As far as the mandible is concerned, the chief points in which, according to Depéret, *Brachyodus* differs from *Anthracotherium*, are: (1) The mandibular ramus in the region of the cheek-teeth is not so deep, its lower border is curved instead of nearly straight, the symphysis is less prolonged backwards and must have been less elongated, and there is only one dental foramen instead of two or three. (2) The lower molars are arranged in a continuous series, there being no diastema between pm. 1 and pm. 2, and at the same time these premolars are shortened in correlation with the shortening of the mandible. (3) In the lower molar teeth the inner tubercles are higher and less massive. The outer tubercles are more compressed in a V-shape; the postero-external tubercle unites by its anterior end with the postero-internal tubercle, as in *Ancodus*. The talon of m. 3 is less developed, and bears a single tubercle only,

[1] Depéret, "Ueber die Fauna von Miocänen Wirbelthieren aus der ersten Mediterranstufe von Eggenburg": Sitz. k. Akad. Wiss. Wien, Bd. civ (1895), p. 397.

[2] Gervais: Zool. et Pal. franç., 1e éd., t. i, p. 96; 2e éd., p. 190.

[3] Neumayr, "*Hyopotamus*-reste von Eggenburg": Verh. Geol. Reichsanstalt, 1883, p. 283.

instead of two of about the same height. (4) The presence of a thick, unbroken ridge of enamel (cingulum) which surrounds the base of the cheek-teeth, particularly the upper molars; this ridge is scarcely indicated in *Anthracotherium*. (5) The presence of a peculiar sculpturing of the surface of the enamel into fine wavy ridges.

The following characters of the mandible and lower teeth are mentioned by Depéret as distinguishing *Brachyodus* from *Ancodus*: (1) The jaw of *Brachyodus* is less elongate anteriorly, there is no diastema between pm. 1 and pm. 2, and the crowns of the teeth are more brachyodont; (2) the lower cheek-teeth of *Ancodus* have no cingulum, and the enamel is not sculptured. On the other hand, according to this writer, there is great similarity between *Brachyodus* and *Ancodus*, both in the form of the mandibular ramus and in the structure of the lower molars. This diagnosis is largely founded on the specimen from Eggenburg, excellent photographic figures of which are given in the above-mentioned paper.

Certain points in the comparisons of these types just quoted seem open to objection. For instance, in specimens of the teeth, both of *Anthracotherium* and *Ancodus*, in the British Museum (Natural History), the enamel is sculptured, and some teeth of *Ancodus* approach those of *Brachyodus* very nearly in this respect. Again, judging from Depéret's figure, the cingulum is very slightly developed in the lower molars, particularly on the inner side; this is also the case in our specimen. In the description of the lower molars the following sentence—"der rückwärtig äussere Hügel heftet sich mit seinem vorderem Rande an den entsprechenden inneren Hügel wie bei *Ancodus*, und nicht mit seinem rückwärtigen Rande;"—is obscure, but it seems to imply that the anterior horn of the postero-external crescent (hypoconid) unites with the postero-internal tubercle (entoconid), as in *Ancodus*, and does not extend across the valley to the antero-internal cusp (metaconid); in the photograph of the Eggenburg specimen it can be seen that this is not so, the arrangement being like that shown on the accompanying Plate XXIII, Fig. 2. Some very worn molars of *Ancodus* show traces of a similar arrangement, which is the normal one in the molars of *Anthracotherium*.

The specimen now figured agrees in all important characters with that from Eggenburg, and must be referred to the same genus. It, however, belonged to a rather smaller animal, in which the crowns of the molars are longer in proportion to their width than in *B. onoideus*, and the dental foramen is smaller and situated beneath the anterior edge of pm. 4, instead of beneath pm. 1, differences which justify its specific separation suggested by Dr. Blanckenhorn. The length of the fragment is 21 cm.

In m. 3 the cingulum is fairly prominent on the antero-external angle of the tooth and on the outer side of the talon; on the inner side it is wanting entirely, except for a short distance on the inner side of the talon. The talon is large, and consists of a single crescentic cusp, similar to the outer cusps of the anterior portion of the tooth, but with the opening of the V looking forward and

inwards instead of inwards only. The outer limb of the V runs to the base of the internal cusp of the pair in front (entoconid), while the inner limb forms the inner border of the talon; between the arms of the V is a rudimentary cusp, which is wanting or scarcely perceptible in *Ancodus*, but which in *Anthracotherium* is large, and in fact equal to the V-shaped outer cusp and standing in the same transverse line with it; indeed, in the form of the talon *Brachyodus* is intermediate between the older genera. The structure of the other molars will be seen in the figure (Fig. 2); it is closely similar to that of the molars of *B. onoideus*. The fourth premolar is a very massive tooth, with one high cusp, from which radiate three ridges; one, running to the antero-internal angle, the second to a point a little behind the middle point of the tooth, while the third runs directly backwards, and terminates in a much worn tubercle on the prominent heel of the tooth; the cingulum is well developed on the anterior and posterior ends, and also on the anterior half of the inner side. Pm. 3 in this specimen is represented only by its two fangs imbedded in their alveoli; anterior to this the jaw is broken away.

The arrangement of the anterior premolars is shown in two other specimens, one of which is figured (Pl. XXIII, Figs. 3, 4). In this the second premolar is still in position; it has two roots, and its form is shown in Figs. 3 and 4. Immediately in front of it is the alveolus of the single-rooted first premolar. In front of this the upper border of the jaw was thin and sharp-edged; it is broken away about 20 mm. in front of pm. 1; no trace of the socket of the canine is visible, and from the form of the mandible it is improbable that this tooth was developed into a large tusk. The dimensions of the teeth are:—

	Length.	Greatest width.
m. 3	51 mm.	25 mm.
m. 2	36 ,,	24 ,,
m. 1	25 ,,	17 ,,
pm. 4	27 ,,	17 ,,
pm. 3	? ,,	? ,,
pm. 2	22 ,,	13 ,,

The wide distribution of this Lower Miocene Anthracothere is notable, and I think that probably, as Depéret has suggested, the Siwalik forms *Hyopotamus giganteus* and *Anthracotherium hyopotamoides*, described by Lydekker, belong to this genus also.

EXPLANATION OF PLATE XXIII.

Fig. 1.—Imperfect right ramus of mandible of *Brachyodus africanus* (No. 2,849, type-specimen).

,, 2.—Teeth of above specimen, seen from above.

,, 3.—Fragment of anterior of right ramus of mandible of another individual.

,, 4.—Second premolar, seen from above.

All the figures are rather more than $\frac{2}{3}$ natural size.

(*To be continued.*)

II.—Notes on Subaërial Erosion in the Isle of Skye.

By Alfred Harker, M.A., F.G.S., of H.M. Geological Survey of Scotland.
(Communicated by permission of the Director-General.)

CONSIDERING the prime importance attaching to the subject in almost every branch of geological inquiry, it is not a little remarkable that so little has hitherto been done towards obtaining precise measures of the actual waste of land-surfaces and comparing the rates at which the agents of destruction operate at the present time in different districts. Arrangements have indeed been made during recent years to observe systematically the results of marine erosion on our coast-lines, but concerning the far more important subject of subaërial erosion we have exceedingly few accurate data. Sir Archibald Geikie, in his recent address to the Geological Section of the British Association at Dover, has called attention to one aspect of the question, viz., as it affects estimates of geological time, and has urged the desirability of accumulating observations, which should be, so far as the conditions of the problem permit, of a quantitative kind. The few remarks which follow are based on notes made during four or five years' work on the Geological Survey of the central part of Skye, and it is perhaps hardly necessary to point out that the conclusions arrived at are limited to the same area. Indeed, if such observations are to have any value, it must be by comparison with observations made on similar lines in other districts.

Central Skye is a district of sufficiently varied physical characters. Mountains over three thousand feet high rise within two or three miles of the sea. These, with their subsidiary branches, embrace extensive corries, drained by streams which have a high gradient, and become in flood-time formidable torrents. Beyond the mountain-tract are deeply eroded basaltic plateaux, rising in places to 1,500 feet or more above sea-level. The rainfall is probably the heaviest in Britain, or indeed in Europe, amounting to as much as 100 or even 150 inches at sea-level, and doubtless much more among the mountains, while the district is swept during the greater part of the year by winds which often rise to severe gales of several days' duration. A newcomer to such a district might well expect to find decisive evidence of the continued activity of eroding and transporting agencies, but such expectation, as I shall show, would not be realized.

Skye, in common with the other islands of the Inner Hebrides, has often been cited as a striking example of the visible results of subaërial erosion, and it would be difficult to find in the British Isles a district more instructive in this respect. Lava-flows of Eocene age present their truncated edges on the hill-sides to a total thickness of thousands of feet. The gabbro and granite are of later date than the lavas; yet these plutonic rocks, consolidated doubtless under a thick covering of the basaltic lavas, now form the highest ground in the district. My thesis is that the vast amount of erosion

thus attested is almost wholly referable to middle and later Tertiary times, the remaining and final touches being added by the ice and frost of the Glacial period. Under existing conditions the processes of degradation are practically at a standstill, and the total result of subaërial erosion since the disappearance of the glaciers has scarcely left its mark even on the minor details of the surface-features.

There is, of course, no anomaly in this, if we view it in connection with the principle that the efficiency of the agents of erosion is necessarily controlled by movements of upheaval and depression in the area concerned, an aspect of the question which has too often been neglected by geologists on this side of the Atlantic. Although the latest movement of land relatively to sea, of which we have direct evidence in the district, is one of elevation to the extent of about 100 feet, it cannot be doubted that the land-sculpture which gave the district its existing mountain and valley system was effected at a time when the country stood at a considerably higher level than at present. Desiring rather to record observations of fact than to enter into theoretical discussions, I will not pursue this subject. There is, however, one general question upon which I feel constrained to make a few remarks, viz., the share of ice-erosion in producing the existing surface-relief.

The writings of some geologists during recent years show a tendency to depreciate the importance of ice as an eroding agent. How this attitude is to be justified on *a priori* grounds it is not easy to understand. A pebble or a sand-grain held firmly in the grip of a glacier must certainly be a more efficient graving-tool than one rolled along the bed of a river, and the disparity in the same sense becomes more evident when we take into account the great pressure which must exist at every point of contact beneath a great thickness of ice. We shall not, however, assign to ice-erosion its due part in the total results produced unless we recognize that

FIG. 1

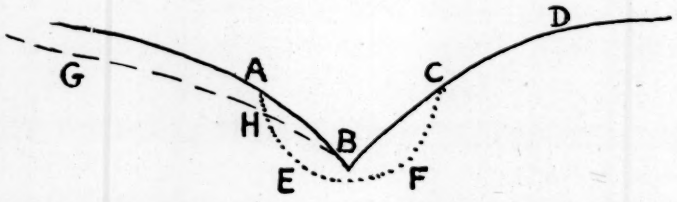

FIG. 1.—Transverse section of valley: ABCD initially, AEFC after modification by glacial erosion. Longitudinal profile of tributary glen: GHB initially, GHE after modification.

its effects differ to a great extent *in kind* from those of water-erosion. Some of these peculiarities I have specified in a recent number of this Magazine (May, 1899, pp. 196–9) without attempting to discuss their *rationale*. But, although a complete analytical treatment of the subject would be difficult, it is easy to see that the peculiarities in question connect themselves readily with the

distinctive characteristics of ice-drainage as contrasted with water-drainage. Thus, a glacier occupies the whole width of its valley, while a river and its tributaries mostly follow narrow and defined paths: hence the peculiar U-shape of the glaciated valley and the precipitous descent by which a tributary glen joins the main valley (Fig. 1). Again, the amphitheatre form of the head of a glaciated valley connects itself with the fact that, while erosion near the sources of a river is very feeble, a glacier, on the other hand, springs into being, like Athene, fully armed. The dependence of glacial erosion upon the pressure, and so upon the thickness of the ice at any point, seems to offer an explanation of other characteristic features, such as the exaggeration of slight inequalities of gradient in a valley into precipitous drops (Fig. 2) and the excavation of small rock-basins.

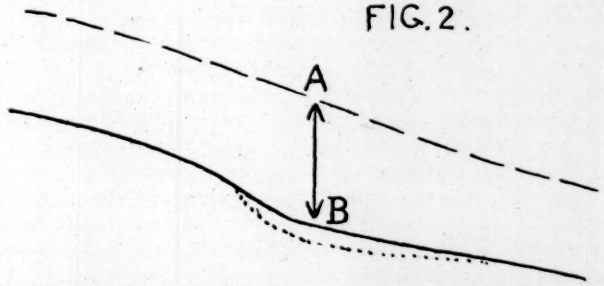

Fig. 2.—Longitudinal profile of valley occupied by glacier. Owing to inequality of gradient, the thickness of the ice at AB is greater than either above or below that place. The consequent more rapid erosion at B has the effect of exaggerating the inequality.

As distinguished from the erosion due directly to ice action, we have to note further the disintegration caused by frost in the later stages of the Glacial period. Nothing in the scenery of the Cuillins is more striking than the sharp contrast of the splintered and jagged summit-ridges with the rounded and polished surfaces of the corries and the lesser heights. The first impression is that the higher peaks have stood out above the ice, and so escaped the moulding and smoothing which have left their impress on the lower slopes; but in attempting to follow out this idea in detail many difficulties are encountered. Moreover, the movements of the ice, as traced out in the course of a complete survey, and the history of the glaciation of the district as a whole, almost compel us to the conclusion that, at the stage of maximum glaciation, the whole district was covered, even to the highest summits. Later, when the ice was reduced to gradually shrinking valley glaciers, the uncovered summit-ridges would be subjected during a long time to conditions highly favourable to the shattering and splintering of which they give evidence. In no other way can we account for the huge talus, often composed of large unworn blocks, which chokes the upper part of so many of the mountain valleys, being specially well displayed in the southern branch of Coireachan Ruadha and along the whole extent (a mile

in length) of Garbh-choire. In their situation and condition these coarse screes often differ markedly from true stone-falls or from the waste of an escarpment in more ordinary circumstances. Some of the blocks have evidently fallen upon some soft cushion, such as snow; others could not reach their actual position by merely falling and rolling; others, again, have been derived from the rock upon which they rest. Screes of this kind must be regarded as, in a sense, Glacial accumulations, and, indeed, it is sometimes impossible to separate them in mapping from true ice-borne débris. The additions from later stone-falls are quite insignificant. What is true of the Cuillins, the gabbro mountains, seems to be true also of the Red Hills, formed of granite, though it is less easily demonstrated. The screes which conceal much of the slopes of these hills are not to be separated from the boulders which often cover the flat or gently rounded tops, and these are much more regularly distributed than, e.g., the blocks which build the tors of Dartmoor and other granite plateaux. Chemical, co-operating with mechanical, degradation has caused a sensibly greater post-Glacial waste of the general surface here than elsewhere in the district, but it is probably still of trivial amount, being measured by the slight projection of the occasional basalt dykes above the granite which they traverse.

Assigning, then, to the screes in general a Glacial age, it may be stated that post-Glacial erosion in the district is almost limited to the clearing out of the pre-Glacial channels by the removal of the boulder-clay which filled them. Not the valleys, but only the water-courses have been cleared, and these not always completely. On the lower ground, where the declivities are slight and the drift in places thick, streams seem in a few instances to have been diverted for some distance into a new course, but in no case is a new channel cut into rock. It will also be shown below that, when we speak of boulder-clay being removed, this is to be understood of the clay itself, not of the contained boulders. The courses of the minor streams in the drift-covered country are determined by the superficial features of the drift itself, which remain practically without change. Here and there a burn, winding its way among the tumulus-like mounds of the 'kettle moraine,' has trenched upon the steep slope of one of the mounds, but the smaller streams usually flow over turf or peat. The mountain torrents, which drain the bare rocks of the higher corries and fall in cascades over their rocky barriers, give even less indication of post-Glacial erosion. Sometimes they are guided by dyke-fissures, but as a rule there is no channel at all: the water glides over the polished rocks in a spreading sheet, through which the glacial scorings appear as distinct as elsewhere on the smooth surface. As might be inferred, the streams throughout the district are found to be wholly free from sand or other detritus.

Two localities in the district are worthy of special notice as illustrating the foregoing remarks. One is Eas Mòr, the most considerable waterfall in the Cuillins, on the lower part of the burn draining Coire na Banachdich. Here the burn plunges over a nearly

vertical precipice of 140 feet into a steep-sided winding gorge, which continues for some 300 yards. The fall is caused by an irregular sheet of a fine-grained gabbro, more durable than the prevalent coarse type in the neighbourhood, and the gorge, at least as regards its upper part, results from the cutting back of the fall. Here, if anywhere in the district, we should find evidence of active erosion at the present time, and one or two small stone-falls of evidently recent date at the upper end of the gorge suggest at first glance that the cutting back may be going on rapidly. A closer examination, however, negatives this supposition, and proves that practically the whole of the gorge must have been cut out in pre-Glacial times. The boulder-clay by which it has been filled is for the most part cleared out from the bottom of the gorge, though some relics remain intact, the nearest being about thirty yards from the waterfall. The post-Glacial recession cannot, however, have amounted to anything like thirty yards, as appears from examining the rim of the gorge. The head of it is expanded into a relatively wide cauldron (itself a significant feature), and the drift is found to creep down the steep slopes of this cauldron in such a way as to leave little doubt that it has once been banked up against a face very nearly coincident with the present precipice of the waterfall.

The other locality alluded to is the Sligachan River, in the neighbourhood of the bridge, and its interest is with reference to the transport of material downstream. This river is one of the principal streams of the district, and is also liable to sudden floods in time of rain, rising sometimes five or six feet in a very short time. Like all the other streams, it is perfectly clear, even in the heaviest spates. The idlest lounger on the bridge cannot fail to remark that while the boulders in the bed of the river have dark blue and rusty brown colours (basalt and gabbro), those in the tributary stream on the right, which joins the river just below the bridge, are white or of pale tints (granite). Observing further that below the confluence the left bank of the river is dark and the right bank pale, he may perhaps conclude that the main river drains an area of dark rocks and the tributary burn an area in which the pale predominates. A little more examination, however, will compel him to abandon this explanation, for he will find that the pale boulders creep obliquely across the river until they occupy the whole of the bed, and the broad shingle-flats between and near tide-marks in the estuary below are composed essentially of white and yellow granite.

The key to the puzzle lies in the fact that here, as throughout the district, the boulders and gravel—coarse or fine—in the bed of a stream have no direct relation with the solid rocks of the drainage-basin, but depend solely on the constitution of the drift deposits in the immediate neighbourhood. Where there has been no drift, there are no pebbles in the burns. Where a burn has had to re-excavate a channel through the drift, it has done so by merely removing the finer material, the enclosed stones, large and small alike, remaining as boulders and gravel in the bed of the stream. They may have travelled downstream for a certain distance, but

this distance is always small; in the particular instance selected it is capable of fairly accurate measurement, as follows. The upper part of Glen Sligachan has the Red Hills on the right and the Cuillins on the left. Accordingly we find that granite boulders largely preponderate in the drift on the right side of the valley and gabbro boulders on the left, and a sharp line of division can be drawn along the middle of the valley. Lower down, where the floor of the valley consists of basalt, this rock enters increasingly among the boulders; but the line can be traced to Sligachan and for some eight or nine miles beyond, affording important information concerning the course of the great Sligachan glacier. In the neighbourhood of Sligachan itself this line can be laid down with considerable precision, certainly within a very few yards. As shown by the broken line in Fig. 3, it crosses the river just below the bridge, and thence follows a westerly direction. The dotted line in the figure marks the corresponding division among the stones in

FIG. 3

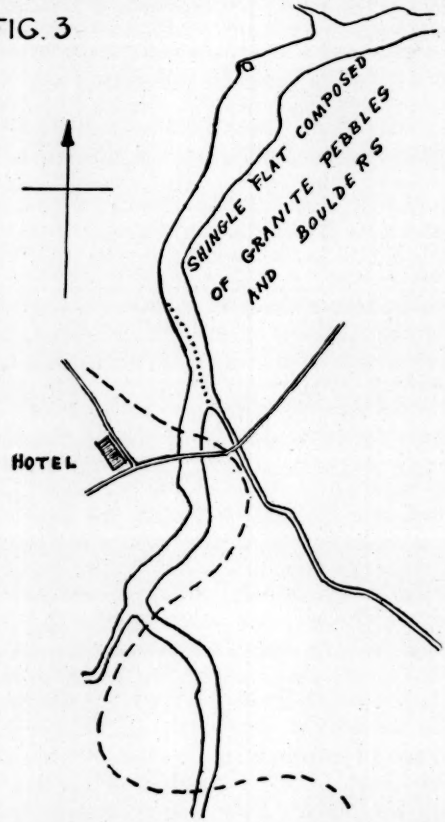

FIG. 3.—Sketch-map of Sligachan River in the neighbourhood of Sligachan; scale, six inches to a mile. Explanation in the text.

the bed of the river, granite largely predominating on the right and being almost wanting on the left. The distance between the two lines thus represents the total downstream movement during post-Glacial times. It is between eighty and ninety yards as measured along midstream, being less along the right bank and more along the left. No distinction has been made between small pebbles an inch in diameter and boulders a foot or more, so that the result obtained expresses the average amount of displacement of the whole collectively. Doubtless the small stones have travelled farther with the stream than the large, and indeed this appears clearly when we examine other places at which the same river crosses the dividing-line in the drift. There are six such places above Sligachan bridge, and at such of them as afford suitable conditions for observation a variable amount of downstream transport can be verified. It reaches nearly 250 yards in the extreme case, this being for fine gravel.

One remark is necessary to guard against misunderstanding. It is not asserted that a stream like the Sligachan River is not *competent* in times of flood to move even large boulders with ease; only that it does not do so to any important extent at the present time and under natural conditions. A state of equilibrium has been attained, in which the stones are so packed as to support one another and offer the greatest possible resistance to the stream. The displacement by any means of a keystone may cause movement among others adjacent to it, just as stepping-stones artificially placed may be swept away by a heavier spate than usual. The following observation is instructive in this connection. The positions of a number of boulders in the Sligachan River were noted by stretching a string from bank to bank and marking where the string fell upon each boulder. After a year and a half, examination showed that only one of the train had suffered any appreciable displacement, and this boulder, which had been moved (by sliding, not rolling) two feet or more downstream, was one of the largest in the neighbourhood, weighing probably not less than three-quarters of a ton. The circumstances left no reasonable doubt that its movement had been rendered possible by the artificial displacement of smaller stones which had served to protect and support it. Indeed, it may fairly be conjectured that the downstream displacement of eighty or ninety yards recorded near Sligachan bridge is mostly of comparatively late date, and is due in great part to disturbances consequent on the movements of anglers. A similar remark applies to loose screes among the mountains. I have observed no sliding of scree-material that was not directly due to sheep or to shepherds and other pedestrians, and it is probable that before the introduction of sheep during the present century there was no such sliding. To whatever class of phenomena we turn, we are led to the same conclusion, that in the district discussed the agents of atmospheric degradation, erosion, and transportation are at the present time almost wholly inoperative, and have accomplished only insignificant results during the whole of post-Glacial time.

III.—On Fossil Dormice.

By Dr. C. I. Forsyth Major, F.Z.S.

In the nomenclature of fossil Myoxidæ, the generic term *Myoxus* has hitherto been used in a broad sense, under the assumption that the distinctive characters of the recent genera of the family are not apparent in their Tertiary representatives. It is my purpose to show in the present note that this is not the case, there being in the Middle Miocene, at any rate, two forms of Myoxidæ, one a *Muscardinus*, the other an *Eliomys*, which have been mixed up together by several previous writers, under the name *Myoxus Sansaniensis*.

1. Muscardinus Sansaniensis (Lartet).

Myoxus Sansaniensis, Lartet: Notice Colline de Sansan, 1851, p. 20. P. Gervais: Zool. Pal. Fr., 2e éd. (1859), p. 37, pl. xliv, figs. 14–19. Lydekker: Cat. Foss. Mamm. Brit. Mus., part i (1885), p. 224. H. Filhol: Ann. Sc. Géol., xxi (1891), 1, p. 39, pl. i, figs. 9, 10. ? Depéret: Arch. Mus. Lyon, v (1892), p. 51.

? *Myoxus niteloides*, Depéret: Arch. Mus. Lyon, iv (1887), p. 154, pl. xiii, figs. 15, 15*a*.

Myoxus Zitteli, Hofmann: Abh. k. k. Geol. Reichsanst., xv (1893), 6, p. 43, pl. iii, figs. 15, 16.

As regards the shape and relative proportions of its cheek-teeth, the recent *Muscardinus avellanarius*[1] is more specialized than either *Eliomys* or even *Glis* (*Myoxus*). The premolar is more reduced than in the latter two genera, owing to its being interfered with by the incisor;[2] apparently by way of compensation, the first true molar is increased in length. Moreover, the triturating surface of the molars of *Muscardinus* exhibits the shape of a rasp much more pronounced than in the above-mentioned two genera. This conformation is quite unique amongst mammalian teeth; the molars of *Elephas* have been compared with those of *Muscardinus*, but they are hypselodont in the extreme and exhibit on their crown an alternation of layers of enamel, dentine, and cementum, whereas those of the latter genus are probably the most brachyodont of all mammalian teeth.

We might expect that fossil members of the genus will show a more normal condition of their teeth than *Muscardinus avellanarius*; this is, in fact, in one respect realized in the left upper jaw of a dormouse, which more closely approaches to *Muscardinus* than to either *Eliomys* or *Glis*, and which I therefore consider as a species of the former genus. I collected it some years ago in the Middle

[1] It is almost generally admitted that the genus is represented by only one recent species. However, the Italian *Muscardinus* rejoices in two specific names: *Myoxus speciosus*, Dehne, from Tursi in the Basilicata, Southern Italy (Allg. deutsche naturhist. Zeit., 1855, p. 180); and *Muscardinus pulcher*, Barrett-Hamilton, from Siena in Tuscany, Central Italy (Ann. Mag. Nat. Hist. (7), ii, 1898, p. 424). I have examined the skull and dentition of the type of *M. pulcher*, and cannot find the slightest difference from Northern specimens. On '*Myoxus speciosus*' see Blasius, Naturg. Säugeth. Deutschl., 1857, p. 298.

[2] Winge, "Om græske Pattedyr": Vidensk. Meddel. Naturh. Foren. Kjöbenhavn f. Aaret, 1881, p. 52 (1882).

Miocene locality of La Grive-Saint-Alban (Isère, France); it is at present preserved in the Geological Department of the British Museum (No. M 5.299). In this fossil the upper premolar, though already reduced in size, is less so than in the recent species, exhibiting four transverse ridges as against two in *M. avellanarius*. M. 1 is not rectangular, as in the latter, but quadrangular. The lengthening of this tooth in the recent species is not, as might have been expected, brought about by an increase in the number of enamel ridges—for there are five of them in *avellanarius*, seven in the fossil—but by a widening of the interspaces between the ridges. In the shape and pattern of m. 2 there is scarcely any difference between the two; *M. avellanarius* exhibits seven transverse ridges, the corresponding fossil tooth six complete and two abortive ridges. M. 3 is the smallest of the true molars in both species. In *M. avellanarius* there are six transverse ridges, more crowded together than in the anterior molars; the fossil tooth is not larger than the recent, but it contains no less than twelve exceedingly minute transverse ridges. Short intermediate ridges are present near the outer margin of all the true molars of the fossil. The length of the four cheek-teeth is $3\frac{3}{4}$ mm.

In the conformation of the premolar and in the reduced size of m. 1, the fossil form therefore approaches towards a more normal condition; it comes near *Glis*, which in its turn is intermediate between *Muscardinus* and *Eliomys*. But in the pattern of the molars, and more especially of m. 3, the Miocene species is still more specialized than the recent species of *Muscardinus*.

The remains from La Grive are by no means the only ones known of this species. Lartet has given the name *Myoxus Sansaniensis* to the smaller of two dormice from Sansan. His description, which I transcribe, is rather imperfect: "Petit Loir de la taille de notre Souris domestique. La couronne de ses molaires est plus compliquée de contours émailleux que celles du *Lérot* et du *Muscardin*, par quoi il se rapprocherait davantage du *Loir* proprement dit. . . . ."[1] However, from the characteristic figures published by Gervais,[2] and from some remains presented by Lartet to the British Museum (Natural History)—No. 33,274[3]—it can be seen that the Sansan dormouse is identical with the one from La Grive. Gervais' figures have met with severe but quite unfair criticism from more than one of the later writers on the subject, because these figures disagree with the teeth of another form of fossil dormouse hereafter to be described, which was wrongly held to be the species noticed by Lartet. Lydekker is quite right when stating that the Sansan specimens in the British Museum (Natural History) agree precisely with those figured by Gervais.[4]

The fragmentary remains from Sansan in the British Museum afford information with regard to the alveoli of the cheek-teeth,

[1] Loc. cit.
[2] Zool. Pal. fr., pl. xliv, figs. 14–19.
[3] See Cat. Foss. Mamm. Brit. Mus., part i, p. 224.
[4] Lydekker, Cat. Foss. Mamm., part i, p. 224.

showing that the fossil species differs from the recent in the number of roots of the upper teeth. A small fragment of the upper jaw exhibits the alveolus of the premolar and that of the first true molar. The former shows that the upper premolar had three distinctly separate roots, like the first true molar, though minuter and more crowded together than in the latter. In both, two minute roots are situated externally, a larger one internally. This conformation of the roots of *Muscardinus Sansaniensis* is confirmed by an examination of the fossil jaw from La Grive, from which it further appears that the three roots of m. 2 and m. 3 are arranged in the same manner as in the anterior teeth.

In *Muscardinus avellanarius* the upper premolar is one-rooted. The roots of the first true molar are described by Nehring as follows: "Der erste (langgestreckte) Molar besitzt fünf Wurzeln, deren Alveolen so gestellt sind, dass sie ein Trapez bilden; drei derselben liegen an der Gaumenseite (die mittlere ist sehr zart), die beiden andern finden sich an der Aussenseite des Kiefers." The second and third upper molar each exhibit four roots.[1]

The lower jaws from La Grive at my disposal are: (1) A right mandibular ramus (Geol. Dep., No. M 5,300), in which only m. 2 is preserved. Length of the alveoli of the four cheek-teeth $3\frac{3}{4}$ mm., as in the upper jaw from the same deposit. (2) A fragmentary right ramus, exhibiting the first and second true molars. Amongst the small fragments from Sansan in the Geological Department (No. 33,274) is (1) a mandibular fragment, right side, showing the empty alveolus of the premolar, and the first true molar; (2) a fragment of a right ramus, in which are preserved the first and second true molars. The general character of all these teeth is that of those of the upper jaw. Their crown is perfectly flat; the transverse ridges show no tendency to form tubercles at either the outer or the inner margin, although some of the crests join together on the outer and on the inner side. This occurs likewise in the recent *Muscardinus avellanarius*, but to a lesser extent than in the fossil. M. 1 is of slightly less size—shorter and narrower—than m. 2, and considerably shorter than m. 1 of *Muscardinus avellanarius*, also differs from it in the same manner as does the corresponding upper tooth of the fossil from that of the recent form. This tooth in the fossil is almost square; the posterior margin, however, is broader than the anterior. The number of transverse ridges is six in both the fossil teeth preserved (m. 1 and m. 2), besides some incomplete intermediate ridges situated near the inner side. In one m. 1 of La Grive, a much worn tooth, I observe only five complete ridges.

From the alveoli preserved, the number of roots can be made out as follows: one in the premolar, two in the true molars. In the recent species the lower premolar has likewise one root, m. 1 three roots, m. 2 four, m. 3 three.[2]

[1] A. Nehring, "Zum Zahnsystem der Myoxinen": Zeitschr. Gesammt. Naturw., 1879, p. 739.

[2] Nehring, loc. cit.

It seems probable that Depéret's *Myoxus niteloides* from La Grive-Saint-Alban[1] is likewise a synonym of our *Muscardinus Sansaniensis*, a view which Depéret himself advocates in his later publication[2] by uniting his species with *Myoxus Sansaniensis*, Lart., from Sansan. But neither the description nor the figures are sufficiently accurate to decide the matter.

Hofmann[3] has described two fragmentary lower molars from the Middle Miocene of Göriach and recognized them as belonging to *Muscardinus*. He proposes a new specific name, *M. Zitteli*, under the belief that they are a new form, but they belong undoubtedly to the species described by Lartet. The two molars are said to be from the left lower jaw; on p. 43 of the text they are referred to as m. 2 and m. 3, in the table of measurements of p. 44 and on the plate as m. 1 and m. 2. M. 1 (m. 2 of p. 43), at any rate the anterior one of the two according to the text and the plate, is incomplete on the outer side and slightly longer than the other (1·5 : 1·0 mm.). Taking into consideration that in the description of the teeth it is stated that their intermediate crests are near the inner side, it results from the inspection of the enlarged fig. 16 that the one marked m. 2 in the figure is in reality the anterior one, and therefore m. 1; the other, which is slightly longer and damaged on the outer side, marked m. 1, is the posterior of the two. This is on the assumption that the teeth are really from the left lower jaw, as seems most probable. As stated above, in a mandibular ramus from La Grive, m. 2 is slightly larger and also longer than m. 1. Hofmann's further description agrees with *Muscardinus Sansaniensis* from Sansan and La Grive.

2. Eliomys Hamadryas, sp.n.

Myoxus Sansaniensis, Schlosser: Palæontogr., vol. xxxi (1884), p. 97 (79), pl. vi (ii), fig. 46.

The assumption that all the Middle Miocene Myoxidæ are a single species, viz., the one from Sansan, called *Myoxus Sansaniensis* by Lartet, rests on the foregone but, as before stated, quite unjustifiable conclusion, that Gervais' figures of the latter form are inaccurate. Fraas, who was the first to assign this name to Myoxine remains from Steinheim,[4] gives no other reason for this identification. Since Steinheim has a considerable amount of mammalian species in common with Sansan and La Grive, it is quite possible that the small *Muscardinus* of the two latter localities may occur in the former also. But it is very difficult to understand what Fraas had before him, for his statement goes no further than to assert that his fossils from Steinheim belong to the Myoxidæ family: "Die Faltung des Kronenschmelzes ist die der lebenden Arten." From the dimensions

[1] Arch. Mus. Lyon, iv (1887), p. 154.
[2] Ib., v (1892), p. 51.
[3] A. Hofmann, "Die Fauna von Göriach": Abh. k. k. Geol. Reichsanst., xv (1893), 6, p. 43, pl. iii, figs. 15. 16.
[4] O. Fraas, "Die Fauna von Steinheim": Württemb. Naturw. Jahresh., xxvi (1870), p. 180.

given it would appear that part at least of the Steinheim Myoxidæ observed by him probably belong to a larger form than *Muscardinus Sansaniensis*. The roots of the lower cheek-teeth, as described by Fraas, agree with those of the species here described under the above heading.

Schlosser likewise unites the Steinheim species with "*Myoxus Sansaniensis*." But, otherwise, by a true conception of the pattern of Myoxine molars, he considerably improves on his predecessor's work, although provided with much scantier material from Steinheim. A good description and a fairly good figure of the lower molars are given.[1] They are described as exhibiting four transverse crests running completely across the triturating surface, whilst three minor crests, starting from the inner margin, terminate in the middle of the crown. In older specimens a partial fusion between two adjoining transversal crests may occur. The Steinheim species, according to Schlosser, shows affinities with *Glis* (*Myoxus*) as well as with *Eliomys*, sharing with the former the large number of transverse ridges; with the latter the concavity of the crown, surrounded by strongly raised margins.

Further on it will be shown that at La Grive-Saint-Alban the Myoxidæ are represented by a second form, larger than the *Muscardinus Sansaniensis* and otherwise different, belonging to the genus *Eliomys*, and identical with the lower molars described by Schlosser from Steinheim. Filhol was aware that the Steinheim species is distinct from '*Myoxus Sansaniensis*' of Sansan: ". . . . il m'a paru que l'espèce de Sansan était différente de celle de Steinheim, qui a été confondue avec elle."[2] Depéret follows Schlosser by mixing up both in the synonymy of '*Myoxus Sansaniensis*.'[3]

No upper jaws of this larger dormouse from La Grive are at my disposal. This is the more to be regretted as the only upper molars —from the Middle Miocene of the Hahnenberg, Ries—which presumably belong to this species are, according to Schlosser, from an old individual, so that the original pattern cannot be clearly made out; this is, in fact, confirmed by the published figure.[4]

I have found at La Grive two mandibular rami of the left side, at present in the Geological Department of the British Museum (M 5,298), which I hold to be identical with the species described by Schlosser from Steinheim. The mandibular angle is imperfect in both, but on one specimen it can clearly be seen that it was perforate. In one of the specimens only m. 1 is preserved, in the other m. 1 and m. 2, the former of the two being damaged on the inner side. The teeth preserved and the alveoli of those missing show that each of the true molars had three roots, two smaller anteriorly and a larger odd one posteriorly, close to the outer margin of the bone. The broken fragment of the premolar in the one specimen and the shape of its alveolus in the other, prove that the

[1] Loc. cit., p. 97 (79), pl. vi (ii), fig. 46.
[2] Ann. Sc. Géol., xxi (1891), art. No. 1, p. 39.
[3] Arch. Mus. Lyon, v (1892), p. 51.
[4] Loc. cit., pl. vi (ii), fig. 48.

premolar had one root and was rectangular, longer than broad. The crowns of the molars are slightly concave. The unique m. 2 exhibits six transverse crests, two of which are incomplete. Three of the crests swell on the outer margin into three blunt cusps, separated by two indentations of the margin. The second and the fifth crest do not reach the inner side; the first and third, and the fourth and sixth, are united together on the inner side by the raised margin of the crown, leaving in the middle of this internal margin a small opening, which corresponds to the interspace between the third and the fourth crest.

M. 1 is slightly longer than m. 2, and exhibits four cusps on the outer side, which in the one specimen are more distinctly separated from each other than in the other by three indentations. The specimen of m. 1, in which the inner side is completely preserved, shows this to be of the same conformation as the inner side of m. 2. In addition to the six transverse crests of m. 2, the unbroken m. 1 exhibits a mere trace of a supplementary ridge in the interspace between the first and the second crest; and besides, the third crest sends off a ramification into the interspace between the second and the third, near the inner margin.

The slight divergence between the above description and that given by Schlosser is certainly not indicative of two different species. I find variations of a similar kind in different specimens of recent species, as for instance *Eliomys nitedula*, where the minor ridges are sometimes reduced to almost imperceptible knobs. Similar variations of Myoxine teeth are registered in Reuvens' monograph of existing Myoxidæ.[1] For the same reason I do not attach any value to the slight divergences between my two specimens from La Grive, although they might seem to acquire some importance by the fact of being of different size as well. In the ramus with two molars preserved (M 5,298*a*), the alveoli of the four cheek-teeth have a length of $3\frac{3}{4}$ mm., in the other (M 5,298*b*) of $4\frac{1}{2}$ mm.

As to the affinities with recent forms, Schlosser, when considering the Steinheim dormouse to be somewhat intermediate between *Glis* and *Eliomys*, seems to have taken into consideration only one species of the latter, *E. quercinus*. My view that the fossil is an *Eliomys* is supported by the following characters:—

(1) Perforation of the mandibular angle, whereby it agrees with both *Eliomys quercinus* and *E. nitedula*, but differs from *Glis*.

(2) Number and position of the roots.—As shown long ago by Nehring,[2] there is considerable difference between *Glis glis* and *Eliomys quercinus* in the alveoli of lower molars. "Each of the four teeth of *Glis glis* has two alveoli, situated one behind the other and not sharply separated in the anterior tooth. In *E. quercinus* the premolar has only one root, each of the three molars three, two of which are situated anteriorly, one by the side of the other, the third

[1] C. L. Reuvens: "Die Myoxidæ oder Schläfer" (1870).
[2] Op. cit., p. 738.

one posteriorly, near the outer margin of the jaw."[1] From what has been stated before, it follows that the fossil agrees with *Eliomys quercinus* in the number and position of the roots.

(3) Concavity of the crown.—This feature has been already pointed out by Schlosser.

(4) Pattern of the cheek-teeth. — Schlosser remarks that, in opposition to *Eliomys*, the fossil shares with *Glis* the large number of transverse crests. However, the eastern species of *Eliomys*, *E. nitedula*, has quite as many as *Glis*, and in their arrangement agrees more with the fossil than does the last-named genus. In the latter the transverse crests are much more loosely, or not at all, connected by a raised internal margin, so that the triturating surface approaches the form of a rasp, a feature of the molars which is still more distinctly exhibited by *Muscardinus*.

By the specific name *E. Hamadryas*, which I propose for the fossil from Steinheim and La Grive—taking M 5,298*b* from La Grive as the type of the species—I wish to recall its affinity with the recent *Eliomys nitedula*, Pall. (*E. Dryas*, Schreb.). It is distinguished from the latter by superior size and by m. 1 being larger than m. 2, while the reverse is the case in the recent species.

The supposed second species of dormouse from Sansan cannot be seriously considered, because it has not been described; and from the way in which Lartet mentions it, it appears that he entertained doubts about its affinities: "*Myoxus*?? *incertus*.—D'après quelques dents molaires et des os des extrémités annonçant une autre espèce de *Loir* plus grand que le Lérot."[2] *E. Hamadryas* is smaller than *E. quercinus*, whilst this problematic fossil is said to be larger.

It only remains to compare *E. Hamadryas* with the Lower Miocene dormice; but I have scarcely any material for comparison, and, besides, the two horizons have not to my knowledge a single mammalian species in common. Of the three mandibles which are noticed in the Catalogue of Fossil Mammalia in the British Museum[3] under the heading *Myoxus murinus*, Pomel, only No. 31,118, from the Lower Miocene of the Allier (Bravard Collection), is a dormouse. The two others, No. M 1,629, from the Upper Eocene of Caylux, France, as well as No. 34,904, from the Lower Miocene of Puy-de-Dôme, France, belong to the genus *Æomys*, which has been placed by Winge into the family Dipodidæ.[4] The supposed close agreement between the cheek-teeth of M 1,629 and Filhol's figures of '*Myoxus murinus*' only exists so far as the dimensions are concerned.

Of the cheek-teeth only the first true molar is preserved in the right mandibular ramus from Allier (No. 31,118); it shows that

[1] *E. nitedula* has been sometimes considered to be a species of *Glis*. Besides the agreements with *E. quercinus* pointed out in the text, the upper molars of *E. nitedula* likewise decidedly favour the same view, as has been shown by Winge: Vidensk. Medd. Naturh. For. Kjöbenhavn f. Aaret, 1881, pp. 51, 52 (1882).

[2] Op. cit., p. 20.

[3] Part i (1885), pp. 224–5.

[4] H. Winge, "Jordfundne og nulevende Gnavere, etc.": E Museo Lundii, I, iii (1887), pp. 118, 166.

Pomel's description of the molars of '*Myoxus murinus*' is quite correct: "Les molaires ont une forme de couronne plus compliquée que celle du lérot, auxquelles elles ressemblent le plus."[1] We have here, again, the pattern of the *Eliomys* molar, approaching close to *E. Hamadryas*. There are four complete crests, alternating with three rudimentary ones; besides, three tubercles on the outer margin. In addition to the usual indentation in the middle of the raised inner margin, there is a slight indentation on its anterior half as well; and this is about the only difference from *E. Hamadryas* in the pattern of the tooth.

The alveoli of the true molars, however, differ considerably, and show that the lower molars of *Eliomys Pomeli*, Trouess. (= *E. murinus*, Pom.), had each only two roots. The premolar was one-rooted.

In size, m. 1 of *E. Pomeli* is slightly inferior to the corresponding tooth of *E. Hamadryas*, although the length of the whole lower dental series is about the same as in the smaller specimen of the latter species ($3\frac{1}{2}$ mm.).

I conclude the present note by a few remarks on the Pleistocene *Leithia* and on the affinities of Dormice generally.

Mr. Lydekker[2] has proposed a new genus, *Leithia*, for the Pleistocene 'Giant Dormouse' of Malta. He is quite positive in asserting that this fossil does not belong to the Myoxidæ, nor to the 'Myomorpha,' and he inclines to constitute for this genus a separate family (Leithiidæ) of 'specialized Sciuromorpha.' His reasons are twofold:—

(1) The infraorbital foramina are said to be of very minute proportions, thus resembling what obtains in squirrels. This I venture to deny, for it is quite evident that the slit-like appearance of the infraorbital foramen in some of the skulls is due to their crushed condition; in one which is a more normal cranium, the foramen is of considerable size.

(2) The upper cheek-teeth are said to resemble those of Sciuridæ, and are said to be nearest to *Xerus* and *Pteromys*; therefore "it seems not impossible that both types of teeth might be derived from a common stock." With this last proposition I quite agree. It is, however, well known that the same may be said, and with greater truth, of the Myoxine *Eliomys*, the four upper cheek-teeth of which "agree in the main with the corresponding teeth of *Sciurus vulgaris*"[3]—indeed, more so than the teeth of *Leithia* agree with those either of *Xerus* or *Pteromys*.

If no other choice was left save to class *Leithia* and the Myoxidæ with either the 'Myomorpha' or the 'Sciuromorpha,' then, taking the Muridæ to be the type family of the former and the Sciuridæ the type of the latter, they would have to be ranged with the latter,

[1] Pomel: Catal. Méth. et Descr. des Vert. foss., etc., 1853, p. 24.

[2] R. Lydekker, "On the Affinities of the so-called Extinct Giant Dormouse of Malta": Proc. Zool. Soc. London, 1895, p. 860.

[3] H. Winge, "Om græske Pattedyr": loc. cit., p. 51.

which in its essential characters as a family shows a more primitive conformation.

Whilst it seems to me perfectly justifiable to create a separate genus for the Malta fossil, I fail to see any stringent necessity for removing it from the Dormice, with which, as far as our present knowledge goes, it agrees best in the cranial and dental characters, as well as in the conformation of the limbs. The only other group which comes in question is the Anomaluridæ of Winge. But this remark applies equally to the Myoxidæ generally, as was long ago recognized by Waterhouse, followed by Gervais. Both these zoologists gave proof of remarkable perspicacity, the former in approximating *Anomalurus* to the Myoxidæ,[1] the latter in grouping *Anomalurus*, '*Myoxus*,' and the Tertiary Theridomyinæ in one family.[2] Flower and Lydekker[3] place *Anomalurus* in the 'Sciuromorpha,' the Myoxidæ in the 'Myomorpha,' and the Theridomyidæ in the 'Hystricomorpha.'

In support of placing *Leithia* with the Anomaluridæ, instead of with the Myoxidæ, might be adduced, first, its molariform premolars, which are less reduced than even in *Eliomys* or *Glis*; and, secondly, the inner longitudinal 'wall' of its upper cheek-teeth, which is a peculiar feature of *Anomalurus*, but not of *unworn* Sciurine molars. These characters we have to weigh against the Myoxine distal union of the tibia and fibula in *Leithia*. Considering that already within Anomaluridæ occur reduced premolars,[4] and that the aforementioned conformation of the upper molars occurs, within Anomaluridæ, in the genus *Anomalurus* alone, we should best meet all the exigencies of the case by classing the whole of the Dormice, *Leithia* included, at the end of the Anomaluridæ as one of their sub-families, of equal rank with Winge's "Trechomyini, Anomalurini, Theridomyini, and Pedetini."[5] This is about the place assigned to the Dormice by Von Zittel,[6] who, however, constitutes for them and for Winge's Anomaluridæ, etc., a provisional sub-order, the Protrogomorpha, a course which has the advantages but also the defects inherent to compromises. And so has the other course followed in the Handbuch, viz., the retention of the terms *Sciuromorpha*, *Myomorpha*, etc., attaching to them, however, a rather different meaning from that intended by Brandt, who unfortunately is still followed by the majority of zoologists.

For at the bottom of the whole matter, and the cause of all the mischief, are the 'hard-and-fast' divisions into which the Rodent genera are up to the present day being forced. If we continue to cling to the 'time-honoured' but unnatural sub-orders *Sciuromorpha*,

[1] Proc. Zool. Soc. London, 1842, p. 126.
[2] Zool. Pal. Fr., 2e éd. (1859), p. 27.
[3] "Introduction to the Study of Mammals," 1891, pp. 449, 459, 484.
[4] For example, in *Zenkerella* (*Aëthurus*). Cf. W. E. de Winton, "On a New Genus and Species of Rodents of the Family Anomaluridæ": Proc. Zool. Soc. London, 1898, p. 450.
[5] H. Winge, "Jordfundne og nulevende Gnavere": loc. cit., 1887, p. 118.
[6] "Handbuch der Palaeontologie," I, iv (1893), p. 526.

Myomorpha, and *Hystricomorpha* of Brandt, we cannot hope to gain an insight into the mutual affinities of the various groups of the order. These sub-orders are unnatural because (1) they ignore the fossil Rodentia and the lessons taught by them; (2) in some instances they present an amalgamation of heterogeneous groups; and (3) they draw barriers where in reality there are none. Winge, by pulling down these artificial barriers, has taken the bull by the horns, and we cannot do better than follow him.

IV.—On the South-Eastern Coalfield.[1]

By Professor W. Boyd Dawkins, M.A., F.R.S.

THE discovery of a coalfield in 1890 at Dover, in a boring at the foot of Shakespeare Cliff, has been already brought before the British Association by the author at Cardiff in 1892, and is so well known that it is unnecessary to enter into details other than the following. The Carboniferous shales and sandstones contain twelve seams of coal, amounting to a total thickness of 23 feet 5 inches. These occur at a depth of 1,100 feet 6 inches below Ordnance datum, and have been penetrated to a depth of 1,064 feet 6 inches, or 2,177 feet 6 inches from the surface. They are identical, as I have shown elsewhere,[2] with the rich and valuable coalfields of Somersetshire on the west, and of France and Belgium on the east. The discovery is of great practical value, as it will probably result in the same development in Kent of industries and manufactures which has taken place where the coal has been worked, under the same conditions, beneath the Cretaceous and Jurassic rocks in France and Belgium. It is of equally great theoretical value, as it proves up to the hilt the truth of Godwin-Austen's view, published in 1858, that the Coal-measures lie buried underneath the newer rocks in South-Eastern England.

After the boring was completed in 1893 the discovery lay dormant until in 1897 the Kent Collieries Corporation began to sink shafts on the site of the boring, and to put down boreholes at Brabourne and Pluckley, in the Weald of Kent, to verify the range of the Coal-measures in the property which they held under lease.

The Mid-Kent Coal Syndicate also put down a boring at Penshurst, and the Kent Coal Exploration Company began work in various parts of eastern Kent. The borings of the two latter undertakings have been carried on under my supervision, and none of them, as yet, is completed. They, nevertheless, throw important light on the range of the Coal-measures in South-Eastern England, and are not unworthy of being brought before this meeting of the British Association.

The first boring to be noticed is at Ropersole, a spot near the highway between Dover and Canterbury—eight miles from Dover, at 400 feet above O.D.—the surface being composed of Upper Chalk,

[1] A paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Proc. Royal Inst., June 6, 1890. Trans. Manchester Geol. Soc., xxii, Feb. 2, 1894; xxv, Feb. 9, 1897.

with a thin stratum of Clay-with-Flints. It was begun at the close of 1897, and has at the present time pierced the strata to a depth of 1,773 feet 7 inches.

It is being carried out under the able superintendence of Mr. James Newton, resident engineer, with the calyx drill, and the occasional use of a diamond crown for the lower and harder rocks. The result in both cases is a solid core. The section is as follows :—

ROPERSOLE, 400 O.D.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
UPPER CRETACEOUS (953 feet)	Upper Chalk	480	0	480	0
	Middle Chalk	118	0	598	0
	Lower Grey Chalk ...	220	0	818	0
	Glauconitic Marl ...	16	0	834	0
	Gault	119	0	953	0
NEOCOMIAN (72 feet)	Lower Greensand ...	51	0	1,004	0
	Atherfield Clay	21	0	1,025	0
	Purbeck-Wealden Beds	55	0	1,080	0
OOLITIC (473 feet)	Kimmeridge Clay (?) ...	10	0	1,090	0
	Corallian	157	0	1,247	0
	Oxfordian, Callovian ...	142	0	1,389	0
	Bathonian	164	0	1,553	0
LIASSIC (27 ft. 9 in.)	Upper Lias	3	0	1,556	0
	Middle Lias...	24	9	1,580	9
COAL-MEASURES (192 ft. 10 in.)	Shales and Underclays	69	3	1,650	0
	First Coal	0	9	1,650	9
	Shales and Underclays	50	6	1,701	3
	Second Coal	0	6	1,701	9
	Shales and Underclays	22	3	1,724	0
	Micaceous Sandstones...	49	7	1,773	7

The Coal-measures contain the usual Carboniferous plants—*Sigillaria*, *Lepidodendron*, and ferns, and the usual Stigmarian roots and rootlets, and, like those which we struck in the borehole at Dover, are probably horizontal. The coal is bright and blazing, and breaks up into little cubes, but slightly deformed by pressure into the lozenge-shape. In this respect it agrees with the coals of Dover, and like them shows no sign of crushing. The horizontality of the beds in both these cases may be accounted for by the boreholes happening to strike the bottom of a Carboniferous synclinal fold. This conclusion, viewed in the light of the coalfields of France and Belgium, on the one hand, and of Somerset on the other, is more probable than the view that they extend horizontally over a very large area.

It is strengthened by the fact that the rocks, probably Devonian, struck at the bottom of the borehole at Brabourne, some few miles to the west, are inclined at a high angle. They here are a portion of an anticline which is probably related to the Coal-measures above them, as the Devonian axis of the Mendip Hills is related to the syncline of the Somerset Coalfield.

In my opinion the Coal-measures of Ropersole are a portion of the same series as those at Dover. Here, as at Dover, the question of seams of coal resolves itself probably into a question of sinking

deeper. Here only two unimportant seams have been met with in a thickness of 192 feet. There twelve seams were penetrated in a thickness of 1,064 feet 6 inches, the thickest 4-feet seam being at the bottom.

The Ropersole boring establishes the fact that the Dover coal-measures extend northwards for a distance of eight miles and beyond in the direction of Canterbury.

It remains now to see how far the range of the South-Eastern Coalfield has been proved by other borings. None of the three others which are now being carried on by the Kent Coal Exploration Company at Ottinge, Hothfield, and Old Soar to the north of Tonbridge has been carried deep enough to give any evidence. We are, however, indebted to Mr. Etheridge [1] for conclusive proof that its south-western boundary does not extend as far to the south-west as Brabourne. Here a fine-grained grey argillaceous sandstone, in my opinion Devonian, was struck in a boring at a depth of 1,921 feet 5 inches from the surface, the strata being inclined at a high angle, and being covered by a red dolomitic conglomerate of Triassic age, just as similar rocks occur in the central axis of the Mendip Hills. This boring has verified the exact position of the Pembroke-Mendip anticlinal fold, which I mapped in 1894.[2] It ranges in a north-west and south-easterly direction close under the line of the Chalk downs from Folkestone to Wye, a few miles to the north of the theoretical line of my map, and forms the southern boundary of the South-Eastern Coalfield. In Somersetshire it emerges from beneath the Triassic and Jurassic strata in the Mendip Hills, and in Northern France along the low hills sweeping from Hardinghen past Ferques in the direction of Cape Gris Nez, where, as in the Mendip range, it is traversed by many faults.

The Coal-measures set in in Kent at a sufficient distance to the north-east of Brabourne to allow of the presence of the Carboniferous Limestone and Millstone Grit. These probably dip at the same high angle as the Devonian below. Their south-western boundary can only be accurately defined by further borings such as that which we are now carrying on at Ottinge, about two and a half miles to the north-east of the scarp of the Downs, and six miles to the south-west of Ropersole. Their range to the north and the east still remains to be proved. They are, however, continued under the Channel, and have been proved by the boring at Calais in 1850, as well as those carried out in 1898 at Strouannes near Wissant. In this district they are clearly shown by other borings to be faulted into the Devonian and other pre-Coal-measure rocks.

The thickness and value of this South-Eastern Coalfield can only be estimated by the exposed coalfields of Northern France and Belgium and of Somerset. That of Liége is 7,600 feet thick and contains eighty-five seams, presenting an aggregate thickness of 212 feet of workable coal. That of Mons is 9,400 feet, with 110

[1] Brit. Assoc. Bristol Meeting, 1898.

[2] "The Probable Range of the Coal-measures in Southern England": Trans. Federated Institution of Mining Engineers, vol. vi, map.

seams yielding 250 feet of coal. In Somersetshire the coalfield is 8,400 feet thick, the seams are fifty-five in number, and yield 120 feet of available coal. It is obvious from these figures that the possibilities of the South-Eastern Coalfield are very great, although it still remains to be proved how far these great thicknesses of rock have been denuded in Kent before the deposition of the Triassic and Jurassic rocks.

The upper denuded surface of the South-Eastern field was struck at Ropersole at a depth of 1,180 feet 9 inches below Ordnance datum, and at Dover at 1,100 feet 6 inches. If the rocks which have to be traversed above O.D. be added the resulting figures of about 1,600 feet necessary to sink from the surface are well within the depth to which coal is now being worked at a profit in England and in France and Belgium. It is well within the 4,000 feet limit laid down by the Coal Commission of 1872.

The strata overlying the coal-measures at Ropersole and Dover present points of great geological interest bearing on the geographical conditions under which they were formed, as may be seen from the following table :—

TABLE OF COMPARATIVE THICKNESSES OF NEOCOMIAN AND JURASSIC ROCKS AT DOVER AND ROPERSOLE.

	Dover.	Ropersole.
	ft. in.	ft. in.
Neocomian	124 8	72 0
Purbeck-Wealden	94 6	55 0
Oolitic	634 10	473 0
Liassic		27 9

All these rocks are thinning off to the northwards against the Carboniferous and pre-Carboniferous rocks, which form the 'axis of Artois' of Godwin-Austen, as he foresaw in 1858 that they must thin off in South-Eastern England. South and west of the meridian of Dover they thicken very rapidly, the Neocomians being 244 feet, the Purbeck-Wealden of Kent and Sussex being not much less than 2,000 feet thick, and the Jurassic rocks of considerable though unknown thickness. In the Netherfield boring, near Battle in the Hastings district, the Upper and Middle Oolites are proved to be more than 1,700 feet thick.

The evidence of the other boreholes under my supervision proves that the thickening of the Neocomian, Purbeck-Wealden, and Upper Jurassic strata to the south of the downs between Folkestone and Tonbridge is very considerable. It is summed up in the following table :—

	Ottinge.	Hothfield.	Old Soar.	Penshurst.
Neocomian	246	180+	? 50	—
Purbeck-Wealden	146	593	650	1,511
Portlandian	—	—	—	—
Kimmeridge Clay	—	—	—	356+

The Purbeck-Wealden beds also show a considerable thickening to the west, if the boring at Ottinge be compared with that of Penshurst, near Tonbridge, where the boring began low down in the Ashdown Sand, the lowest member but one of the group.

It remains for us to sum up the results of these borings, which are likely to effect the same economic revolution in Kent as was brought about in France by the extension of the coalfield of Valenciennes and Mons, about ninety-five miles to the west of its original outcrop at the surface, and to within some thirty miles of Calais. The coalfield has been proved at Dover. Its range for eight miles to the north has been also proved at Ropersole. Its southern boundary, as yet ill-defined, is marked by the Pembroke-Mendip anticline, ranging under the southern scarp of the chalk downs. Its range in other directions is unknown, and awaits further investigation. To the south of this anticline the Palæozoic floor is probably composed of pre-Coal-measure rocks. If, however, the Coal-measures do occur, they are buried under such great thicknesses of superincumbent rock—largely sands and loams full of water—that it will be difficult to work them. We know now by experiment not only where to seek, but also where it is advisable not to seek for the Coal-measures. The difficult problem of the buried Coal-measures in South-Eastern England, now being worked out by private enterprise, is likely to add greatly to the resources of this country, as it has already added to the wealth of geological knowledge.

V.—Some Recent Work among the Upper Carboniferous Rocks of North Staffordshire, and its bearing on concealed Coalfields.[1]

By Walcot Gibson, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THERE is every reason to believe that in the near future the supplies of coal lying beneath the Red Rocks of the Midland counties will have to be relied upon to meet the increasing demand.

Workable seams of coal have been met with at reasonable depths beneath the Red Rocks surrounding the South Staffordshire Coalfield, but there remain large areas lying between the known coalfields of Shropshire, North Staffordshire, and Nottinghamshire, which have not at present been explored. Within this region, as shown on the published maps of the Geological Survey, there are considerable areas of so-called Permian rocks, which recent investigations have proved to be conformable to the Upper Coal-measures and to contain a Coal-measure flora. Thus Mr. T. C. Cantrill has shown that in the Forest of Wyre the so-called Permian rocks contain thin coal-seams and bands of *Spirorbis* limestone.[2]

Exceptional facilities afforded by numerous marl- and brick-pits and other artificial and natural exposures in North Staffordshire

[1] A paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Quart. Journ. Geol. Soc., vol. li (1895), p. 528.

have enabled Mr. C. B. Wedd and myself to make out the following definite stratigraphical sequence in the Upper Carboniferous Rocks:—

(4) *Keele Sandstone Series.*—Red sandstones and marls, calcareous breccias, fossiliferous (Entomostracan) limestones. Thickness, 700 feet, summit nowhere seen. (= Permian of older observers.)

(3) *Newcastle-under-Lyme Series.*—Grey sandstones, marls, and shales, with four thin coals. Two bands of fossiliferous limestone (Entomostracan) form the base. Thickness, 250 to 300 feet.

(2) *Etruria Marl Series.*—Red and mottled marls, with thin bands of coarse green grit near the summit and base. Thickness, 700 to 800 feet.

(1) *Black Band Series.*—Grey and mottled marls, the grey marl predominating; bands of ironstone with Entomostraca, *Anthracomya*, fish-remains; occasional bands of grit 30 feet thick; several thin coals; numerous zones of limestone and shales with Entomostraca. A band of limestone, constant in position (36 to 40 feet) above the Bassey Mine ironstone, forms the base. Thickness, about 250 feet.

Variability in the character of the deposits of the coal-measures is universal, so that it is hardly to be expected that this sequence will be recognizable in its entirety over the whole Midland area; but there can be no doubt that it is an important point to find out which of these divisions occurs at the surface in the areas at present regarded as Permian or as Upper Coal-measures on the published maps.

Already the determination of the successive divisions above noted has had important industrial bearings. The fact that the Newcastle limestone lies at the base of grey measures intercalated between an upper group of red strata (the Keele series) and a lower group of red strata (the Etruria marls) has enabled me to detect true Upper Coal-measures in Keele Park, Shutlanehead, and to the west of Leycett. Moreover, there seems to be little doubt that the Coal-measures of the Pottery Coalfield lie not far from the surface under Little Madeley and Craddocks Moss. Evidence has been obtained that the strata on the north-west side of the North Staffordshire anticline do not uninterruptedly descend beneath red rocks (so-called Permian) to the west of Leycett, but rise locally westward under Hayes. The effect of this change of inclination is to bring to the surface strata which lie considerably below the unproductive red series, and to bring the principal coals and ironstones within reach further west than might have been expected.[1]

It follows that a thorough and complete examination of the exposed coalfields of the Midland counties and of the bordering New Red rocks will be of the highest importance in determining at what depth the productive measures lie beneath the great central tracts of the Midland counties.

[1] See Summary of Progress of the Geological Survey of the United Kingdom for 1898, p. 123.

VI.—Note upon *Pliohyrax græcus* (Gaudr.) from Samos.

By C. I. Forsyth Major, M.D., F.Z.S.

A MUTILATED skull of an Ungulate from the Upper Miocene of Samos, purchased by the Geological Department of the British Museum in 1894, was in that year (before I left Europe) identified by me as a *Leptodon*, and under this name it was registered (M 5,419).

The types of *Leptodon græcus*, Gaudry, are two mandibular rami from Pikermi, known by the excellent description, accompanied by good figures, in the "Animaux fossiles et Géologie de l'Attique."

The generic identity of the remains from Pikermi and Samos respectively is shown by (1) the general character of the molar teeth, recalling the Palæotheres, Paloplotheres, etc., and among recent groups, more than all, the Procaviidæ (Hyraces), and (2) the special character of the last upper and lower molar. Moreover, the agreement in size entitles us to assign them to the same species:—

Length of lower true molars (m. 1 — m. 3) from Pikermi	95 mm.
Length of upper true molars (m. 1 — m. 3) from Samos	94 mm.

In both specimens, the true molars increase in size from before backward. In the lower jaw from Pikermi m. 3 is provided with a third lobe of unusual dimensions, while the corresponding tooth in the upper jaw of the Samos fossil exhibits also a considerable prolongation of its posterior part. This tooth, by its complication and great length as compared with m. 2 (43 : 25 mm.), presents a character very unusual amongst Ungulates, and for which we find analogies only among fossil Ungulates from Patagonia, more especially several of the Protypotheridæ, from which last I do not think that Ameghino's Archæohyracidæ need be separated. The prolongation of the palate backward beyond the molar series and the posterior position of the infraorbital foramen and orbit are further points of agreement between the fossil from Samos on the one side and the Patagonian Ungulates on the other. The teeth from Pikermi and Samos are rather brachyodont, those of the Protypotheridæ highly hypselodont or rootless; characters which, as matters at present stand, rather oppose the view of a South American origin of the Protypotheridæ.

A skull, also from Samos, in the Stuttgart Museum, described by Osborn in the Proceedings of last year's International Congress of Zoology under the name of *Pliohyrax Kruppii*, corresponds with the London skull in the elevated position of the orbit (which is complete, as shown by the latter fossil), in the extension of the bony palate backward beyond the molars, and in the structure of the molars. The anterior part of the skull, missing in the British Museum specimen, shows the relationship of *Pliohyrax* with *Hyrax* "in the enlarged pair of incisor teeth," which approach more nearly in form to those in female skulls of the recent genus.

In a recent notice by Schlosser (Zool. Anz., Sept. 18 and Oct. 2, 1899), a lower jaw from Samos in the Munich Palæontological Museum is described, and identified both with the *Leptodon* from Pikermi and with the Stuttgart fossil.

A description of the skull in the British Museum (Natural History), accompanied by figures, will be published shortly, when I shall more fully discuss its relations with the fossils described by the French, the American, and the German palæontologists.

The generic name *Leptodon* has to give place to *Pliohyrax*, the former being preoccupied by Sundevall's genus of Falconidæ (1835).

NOTICES OF MEMOIRS.

I.—Note on the Surface of the Mount Sorrel Granite. By Professor W. W. Watts, M.A., F.G.S.[1]

IT has long been known that, when first exposed in the quarries, the granite of Mount Sorrel exhibits a smoothed, grooved, and slightly terraced aspect. As the surface, when first discovered, was covered with boulder-clay, it has been concluded that it was produced by glaciation. The writer has long had doubts with regard to this interpretation, and recent excavations near Mount Sorrel have thrown a new light on the phenomenon. At Hawkley Wood and Nunckley Hill a similar but smaller surface has recently been exposed which is covered by undisturbed Keuper Marl, while a second surface, exposed at Nunckley Hill, has boulder-clay abutting on it. Thus the grooving, terracing, and smoothing, like so much of the scenery in Charnwood Forest, was originated in Triassic times, though locally it may have been somewhat modified by glaciation. The writer wishes to thank Mr. R. F. Martin for calling his attention to these newly exposed surfaces.

II.—Note on Barium Sulphate in the Bunter Sandstone of North Staffordshire. By C. B. Wedd, B.A., F.G.S.[1]

(Communicated by permission of the Director-General of the Geological Survey.)

SPECIAL attention has been directed by Professor F. Clowes to the deposition of barium sulphate as a cementing material of Triassic Sandstone near Nottingham, and he has mentioned numerous places, on the authority of Mr. J. Lomas, where the same mineral has been observed in Triassic rocks.[2]

It may be interesting to record another locality. In a cutting of the North Staffordshire Railway (Audley Branch), three-quarters of a mile south of Alsager Road (Talke) Station, a section of Bunter Sandstone in Merelake Hill shows the cross-like marks common in the Keuper Sandstone of Cheshire and Staffordshire, and due to barium sulphate crystals. A partial analysis, made by my friend Mr. R. Hornby, of the Red Bunter Sandstone of Merelake Hill, showed a considerable quantity of barium sulphate. Occasional veins filling joints consist of barytocelestite, which may also be seen in other sections of the Bunter of Merelake Hill.

[1] Abstract of a paper read before Section C (Geology), British Association, Dover Meeting, September, 1899.

[2] Proc. Roy. Soc., vol. lxiv, p. 374. References to previous papers are given in this article.

III.—The Meteorological Conditions of North-Western Europe during the Pliocene and Glacial Periods.[1] By F. W. Harmer, F.G.S.

No satisfactory explanation has yet been offered as to the conditions under which originated the great sheets of shelly sand known to geologists as the Upper Crag, the littoral deposits of the North Sea in Pliocene times, which contain everywhere (over an area in East Anglia more than sixty miles in length) the dead shells of mollusca in the most extraordinary profusion. No such accumulations are now taking place on the shores of Norfolk and Suffolk, although molluscan life is more or less abundant in the adjoining seas. On the coast of Holland, on the contrary, dead shells are exceedingly common.

The occurrence of such débris is local rather than general, and seems to be due, sometimes to currents, but more frequently to the action of stormy winds, which agitate the sea bottom to a greater or less depth. An examination of the daily weather charts issued by the Meteorological Office shows that movement of dead shells towards the shore at any place is for the most part in the direction of the gales which may be prevalent. At present the cyclonic disturbances, to which East Anglian storms are due, pass as a rule with their centres to the north-west of that district; and hence south-westerly and westerly gales are there common, and shelly débris is driven on to the shores of Holland, and not on to those of the east of England. It would seem, therefore, that during the Pliocene epoch strong winds from the east must have prevailed in the Crag area. At an early stage of the Red Crag period, mollusca now confined to the Arctic Circle had begun to establish themselves in the Crag basin, so that the glaciation of Scandinavia, attended with anticyclonic conditions over that country, had probably then commenced. At present, when Scandinavia is anticyclonic, storm centres may be diverted from their usual course towards the south, as was the case, for example, in October, 1898, causing south-easterly and easterly gales, with rough sea on the eastern coasts of England. It is suggested that such conditions may have frequently prevailed there during the Crag period.

The meteorological conditions of the Northern Hemisphere during the Glacial epoch must have been widely different from those of our own time. At present the accumulation of ice-sheets in the Arctic regions is local rather than general; Greenland, for example, being glaciated, while the north of Scandinavia enjoys a milder climate. The latter is due, partly to the Gulf Stream, but partly also to the prevalence of south-westerly winds, caused by the relative positions occupied by areas of high and low pressure. Nansen states that a constant area of high-pressure now exists over Greenland, and that the winds blow outwards from that country in all directions. Similar conditions probably obtained during the Glacial Period over the great ice-sheet of Northern Europe, producing

[1] Read in Section C (Geology), British Association, Dover Meeting, Sept. 1899.

the most far-reaching changes on the climate of different parts of the Northern Hemisphere; and this may, to some extent, explain the local character of the accumulation of great masses of snow and ice during that epoch.

REVIEWS.

I.—The Survey Memoir on the Scottish Uplands.[1]

(*Concluded from p.* 479.)

THE volume opens with a preface by the Director-General giving in outline the *raison d'être* of the work, the mode of its preparation, and the names of the Survey officers concerned in working out the geological facts and phenomena described. In Chapter I a very short description is given of the physical characteristics of the Upland region; and then in Chapter II, a "History of Previous Researches among the Silurian Rocks of the South of Scotland," the writers enter upon the subject-matter of their work in earnest. In this second chapter the whole history of research in the Uplands is passed in review, from the days when Hutton and Hall laid here the foundations of stratigraphical and tectonical geology, down to the present time. The work of all the chief stratigraphical investigators—Moore, Nicol, Harkness, Sedgwick, Murchison, and others—is first noticed in outline. There are abundant references to those palæontologists who have studied the fossils of these rocks—Salter, McCoy, Carruthers, Hopkinson, Davidson, Henderson, Etheridge, Nicholson, Hinde, etc. An account is given of the earlier *formational* mapping by the Survey officers, and its results summarized, explained, and discussed. Next the work of the *zonal* geologists is taken up, and treated in some detail. And, finally, we have a summary of the progress and results of the Survey revision as carried out in the years 1888 to 1898; from which it would appear that well before the close of 1888 the Survey officers had convinced themselves of the accuracy and availability of the zonal methods, and that since that time they have employed them continuously and successfully in developing the stratigraphy and tectonics of the whole of the Upland region.

It is hardly possible to praise the tone of this chapter too highly. It is evident that an attempt has been made to treat all contributions to the literature of the subject as historical documents, with perfect impartiality. The main conclusions of all observers, official and non-official, are given in brief, and discussed openly and frankly in the light of present geological knowledge and opinion.

In Chapter III we are presented with a summary of the whole geological story of the Uplands, from a stratigraphical point of view. Each of the great Upland formations—Arenig, Llandeilo, Caradoc, Llandovery, Tarannon, Wenlock-Ludlow, and Downtonian—is

[1] Memoirs of the Geological Survey of the United Kingdom: "The Silurian Rocks of Britain," vol. i, Scotland, 1899.

described under the headings of rocks, fossils, and conditions of deposition.

For convenience of description the tableland is divided into five geographical belts, viz.: (i) the Southern Belt, comprising the Wenlock-Ludlow area, which runs along the south-west flanks of the Uplands; (ii) the Central Belt or the Upland region proper, which, forming a continuous band some 25 miles in width, sweeps through the heart of the country from St. Abbs Head to the Mull of Galloway, and is floored mainly by Llandovery and Tarannon rocks; (iii) the Northern Belt, which ranges from Dunbar through the Leadhills region to the sea-coast north of Portpatrick, and is floored wholly by Ordovician (Lower Silurian) strata; (iv) the Girvan (and Ballantrae) area; and (v) the area of the inliers of Lanark and the Pentlands.

It is difficult to say which of the peculiar phenomena of the Upland succession, as now accepted after the researches and discoveries of Messrs. Peach, Horne, and M'Connochie, is the most interesting,—the extraordinary tenuity of some of its rock-formations in some districts when contrasted with their extraordinary thickness in others; the striking monotony of their lithology and fauna in one area, as contrasted with the equally striking variety in another; or, perhaps most remarkable of all, the certainty with which the sequence can be unravelled, in spite of the excessive wrinkling and puckerings which the rocks have undergone.

Three of the massive Lower Ordovician formations of Southern Britain—the Upper Arenig, Lower Llandeilo, and Upper Llandeilo, inclusive—are now known to be collectively represented in the Uplands by a thin sheet of Radiolarian chert, only some 70 feet in thickness, which shows through at the surface in numberless anticlinal forms over an area of some 2,000 square miles. Below this chert sheet lies a basement formation—the Ballantrae volcanic series—with a few Middle Arenig graptolites in its higher members; above it follow shales with Upper Llandeilo graptolites. But the chert sheet itself is as yet barren of all fossils except Radiolaria; so that the rich graptolite fauna of the Upper Arenig-Lower Llandeilo formations (Llanvirn), so remarkable in Southern Britain and Scandinavia for its characteristic tuning-fork graptolites (*Didymograptus Murchisoni*), is in the Uplands conspicuous by its absence.

Almost the same extraordinary condensation marks the succeeding Upland rock groups—the Glenkiln, Hartfell, and Birkhill black shales (Moffat Series)—which in the Moffat country answer to the Upper Llandeilo, Caradoc, and Llandovery formations of Siluria. They contain, however, the richest and most varied graptolite fauna known, and their species group themselves in well-marked, consecutive, palæontological zones.

But as we pass outwards from the typical Moffat region to the north-east, north, and north-west, grey shales, grits, and greywackes come in among the black shales, thickening and modifying each zone in turn, commencing from above; so that finally, when we have

reached the distant Girvan region, all the thin-bedded black shale zones of Moffat have disappeared as such, and are now represented by thick rock sheets of very varied lithological types, rich in most of the classes of invertebrate life. But through all these changes, from end to end of the Uplands, we find at intervals among the arenaceous deposits layers with characteristic Moffat graptolites, which enable us to parallel with certainty all the expanding divisions of the Moffat succession, and trace them from point to point, and district to district, through all their variations in lithology, thickness, and palæontology.

The systematic place and geographical distribution of the zones of the Moffat Series, typical and expanded, being thus established, the remainder of the Upland formations fall naturally into line. The overlying wide-spreading sheet of greywackes and grits (Gala or Queensberry Series) is shown both by superposition and by characteristic graptolites to be the equivalent of the Tarannon. The succeeding formations of Riccarton and the Pentland Hills answer both by systematic position and by fossils to the Wenlock – Lower Ludlow formation; and finally, resting upon these Wenlock-Ludlow rocks in Lanarkshire and Midlothian, come the Scottish equivalents of the Passage Beds (Downtonian) of Siluria.

In Chapter IV Mr. Teall deals with the petrology of the igneous rocks associated with the stratified deposits of the Uplands. Few of the points worked out during the revision of the Upland geology has exceeded in interest the establishment of the facts, that the typical members of the disputed rock series of Ballantrae are true contemporaneous lavas and tuffs, and that all the unquestionably intrusive masses associated with them are, with the exception of a few Tertiary dykes, of pre-Bala age. The Ballantrae lavas belong to a great basement volcanic series of Arenig age, which, underlying the sheet of Radiolarian chert, has now been proved by the Survey to actually show through at the surface, in numberless eroded anticlines, over a collective area of some 1,500 square miles. The lavas are mainly diabases or diabase porphyrites, and are characterized by a remarkable 'pillow structure.' Mr. Teall points out with striking effect how both the structure and the composition of these pillow lavas resemble those of the volcanic rocks similarly associated with Radiolarian cherts in such widely separated localities as California, Cornwall, and Saxony, while their accompanying agglomerates and tuffs call to mind those of the disputed districts of Rhobell Fawr and Predazzo; and further, in almost all these widely separated localities, British and foreign, these peculiar volcanic rocks, both effusive and pyroclastic, are pierced by plutonic or intrusive rocks which agree in certain peculiarities of composition, texture, and structure, and in the difficulties which they present to the geologist who endeavours to determine their relative order of intrusion. It is possible that, as in the parallel case of the igneous rocks with pillow structures, and associated pyroclastic rocks, etc., of the Ordovician of Shropshire and Radnor, we are dealing with a distinctly submarine igneous series, probably extruded at great depths in the sea.

All the foregoing chapters may be regarded as introductory to the main purpose of the volume, namely, the detailed description of the geology of the several districts that make up the Upland region as a whole, and the systematic demonstration, stage by stage, of the true succession of its recognizable formations, and their regional variations, characteristic organic remains, and tectonic development. This occupies the main body of the work from the beginning of Chapter V to the end of Chapter XXIV.

These chapters are illustrated by more than a hundred sketch-plans and sections, scattered through the letter-press, prepared by Mr. Peach from the field observations of himself and Mr. Horne. These figures exemplify the large amount of detailed work demanded in the zonal mapping of a country so complicated as that of the Southern Uplands, and numerous as they are, probably not one of them could have been dispensed with. As a finished model for workers in the zonal methods of geology, we doubt whether anything could excel the sketch-plans of Rae Grain (Craigmichan Scaurs) (p. 102), of Morroch Bay (p. 402), and of the Ballantrae Coast line (p. 433); or the sections of Rae Grain (p. 104) and Bennane Coast (p. 434); or, perhaps most remarkable of all, the sketch-plan and section of Lorg Burn (p. 359). These sketch-plans and sections, insignificant as might appear to the older geologists to be the extent of ground illustrated by each—sometimes only a few thousands of square yards in extent—are not only of vital consequence in the development of detailed local successions, but they present in miniature, again and again, many of the tectonic phenomena characteristic of the region as a whole.

Where so much has been given in this department, it is perhaps ungracious to expect more, but when we look at the sketch-map of the Ettrickbridge-end exposure on p. 121, good as it is, we must confess to a feeling of disappointment. It is evident that this miniature plan affords but a very inadequate idea of the care, time, and labour which must have been expended by the Survey officers on this locality. There is no exposure in the country to the east of the Moffat district so vital for purposes of correlation as the one at this spot; and I know, from personal experience, there is not one which is so difficult of accurate interpretation and representation in detail. The Survey work here has been done so thoroughly that it is well worthy of a double-page map and corresponding sections.

These chapters upon the detailed geology commence with a description of the typical area of the Moffat district, as affording the natural key to the complicated stratigraphy of the Uplands as a whole. The entire sequence of the zones of the Moffat Series is redemonstrated and the published nomenclature accepted. But with the confidence generated by the successful testing and retesting of the zonal methods, the officers of the Survey not only simplify the detailed sections across the typical exposures, but carry more or less generalized sections boldly across country from exposure to exposure. They illustrate the type localities of Dobb's Linn and Craigmichan Scaurs by several new sections, the former by an

improved sketch-plan, and they describe and illustrate *seriatim* all the more important exposures throughout the whole of the Moffat district.

It is evident that the authors take it for granted that the reader is already more or less familiar with my paper on the Moffat Series, and many of the new lines of section may be regarded as supplementary to, or corrective of, those given in that paper. But the new sections are delightfully clear, the descriptions terse and condensed, and our knowledge of the geology of the district is advanced by some important discoveries.

One of the new discoveries made here by the Survey officers is of especial importance. They have ascertained that typical Glenkiln graptolites range up into the two to three feet of black and grey shales overlying the band of Glenkiln Radiolarian cherts above the *Cœnograptus* zone. They have therefore properly classed these shales with the Upper Glenkiln, instead of the Lower Hartfell (*C. Wilsoni* zone), to which they were assigned by myself. They have recognized this special subzone with its characteristic fossils at Dobb's Linn, Hartfell, etc. This discovery enables us to correlate with certainty a group of strata characterized by similar fossils which proved most tantalizing to myself and others in the geology of the Leadhills district and elsewhere.

The sequence of the Moffat graptolite zones having thus been established in the typical area upon an impregnable basis, the officers of the Survey next show how the same palæontological succession obtains in all the exposures of black shales occurring in the Central Belt of the Uplands from St. Abbs Head to the Mull of Galloway. They unravel by means of these graptolite zones the entangled and complicated rock-formations which occur in the many exposures of black shale in this region, and place before the reader in most instances the proofs of their conclusions in the form of sketch-plans, sections, and lists of fossils. They demonstrate, by means of the evidences they bring forward, the identity of the so-called Axial series with the Queensberry group. They show that in some few places where the anticlinal forms have been mostly deeply eroded, as at Trowdale Glen, etc., the entire Glenkiln Series has been cut through, exposing a well-marked Radiolarian chert zone below it, and that in two instances at least even this chert zone has been cut through, laying bare a basement series of volcanic rocks which they parallel with the Arenig volcanic series of Ballantrae.

While the Moffat Series remains practically unmodified when followed from Dobb's Linn along the strike of the beds, every zone retaining more or less its typical characters and thickness, it changes rapidly when followed in the direction of the dip—the sheet of overlying greywackes descending deeper and deeper into the series as we pass to the north, replacing each black shale bed in turn, until by the time we have reached the northern limit of the Central Belt, the arenaceous facies has descended to the middle zone of the collective series—the whole of the Birkhill shales and Upper Hartfell being there represented by a grand thickness of greywackes, grits, conglomerates, and shales.

Everywhere, as in the Moffat country, the massive arenaceous group of the Gala-Tarannon succeeds at once to the Moffat Series throughout the whole of the Central Belt. But it is evident that the assumption of the arenaceous facies by successive zones of the Birkhill division as we pass from the Moffat country northward renders it difficult, if not impossible, to fix in every instance the horizon where the Birkhill strata end, and the Gala beds begin. This monotony of lithological facies is especially tantalizing along the northern edge of the Central Belt, where the arenaceous facies has descended far into the heart of the Hartfell itself. The northern boundary of the Central Belt is presumably defined as the outcrop of the line which divides the local Hartfell from the local Birkhill—i.e., it is the line of division between the Ordovician and Silurian of the Uplands. But the lithological transition between the strata of the two systems is here almost as gradual as that between the Cambrian and Ordovician of other countries, and the line laid down upon the map by the officers of the Survey is therefore admittedly generalized and provisional.

A few observations may here be made with reference to the names of the graptolite species cited in the abundant fossil lists scattered through the work. These lists may each be regarded from two aspects, the one stratigraphical and the other palæontological. Regarded from the stratigraphical aspect the lists subserve well the purposes for which they have been drawn up, namely, those of correlating the beds which contain them with the type zones of Moffat and Girvan. The general association of forms is usually sufficient for this purpose, and the exact identification *in sitû* of every species as at present defined by the graptolithologist is from this point of view a matter of no great moment. But regarded from the palæontological aspect the matter is very different. The names of many of the forms given in the lists must be read as provisional and suggestive only, namely, as those of species which are called to mind by the form detected at the locality: for example, the forms united under *Monograptus Hisingeri* may in reality belong to several distinct species; the same is the case with *M. tenuis*, *M. priodon*, *M. lobiferus*, *M. turriculatus*, *Dimorphograptus Swanstoni*, *Dicranograptus ramosus*, and others.

Here perhaps we may also call attention to a practice of palæontologists, admirable enough in its way, but which, when carried out to the extent displayed in the present work, borders very closely on the ridiculous. We refer to the habit of appending the name of the founder of each species in every instance where that species is cited. For example, such titles as *Diplograptus foliaceus* (Murch.), *Dicranograptus ramosus* (Hall), *Monograptus gregarius* (Lapw.), occur hundreds of times within the cover of this volume. Now there can be no question that it is advisable for the sake of scientific accuracy that the reader should be told what special form the writer regards as the type of the species identified; but having appended the name of the founder to that of the species once in his general table of species and once where it is first mentioned

in the body of the work, the writer has done all that can be reasonably expected of him. Any further reference is uncalled for. Such vain repetition can only add unnecessarily to the amount of the printer's bill, and increase, what is already amply sufficient for scientific purposes, the vanity of the species-maker himself.

In their work among the rocks of the Central Belt, already noticed, the Survey officers were mapping ground where the typical sections had already been worked out and the general sequence ascertained. The aim and end of their researches was that of interpreting the complicated structure of the whole belt in terms of the part. But in their work in the Northern Belt, which ranges from Dunbar, through the Leadhills to Loch Ryan, they were dealing with a country of which little was known and less published. It is true that it was already acknowledged that in this belt the greywacke type of sedimentation had descended well into the heart of the Caradoc (Hartfell) formation, so that all that remained of the black-shale type of the Moffat Series was a degenerate Glenkiln-Hartfell group of the characteristic Moffat facies and tenuity, ranging upwards no higher than the base of the Upper Hartfell. It was also known that this Moffat-like band, although rich in graptolites, is exceedingly difficult of unravelment, not only owing to the incoming of arenaceous and ashy members among the black shales, but also because of the unusually excessive wrinkling and puckering, dislocation and alteration, which the rocks of the country have undergone.

It is perhaps in this Northern Belt that the discoveries of the Survey officers have been most brilliant, and the value of the zonal methods most triumphantly demonstrated by them, but the great difficulty of their task will be appreciated on a study of the numerous sketch-maps and sections given in the chapters which illustrate their researches into the remarkably complicated structure of this region. They show that the 30 feet or so of Barren mudstones of Upper Hartfell age in the Moffat district have here become transformed into a massive series of grey and blue micaceous flags and shales (Lowther or Heriot Shales), with conglomerates and limestone bands. The Survey officers have proved for the first time that to this horizon belong the famous limestone beds of *Wrae Hill*, which they have ascertained are associated with a remarkable contemporaneous series of volcanic rocks, felsitic lavas and tuffs, apparently representatives of the rhyolitic lavas and ashes of Snowdon.

The Glenkiln–Lower Hartfell Series presents marked and often rapid lithological variations. The Lower Hartfell graptolitic black shales with flinty bands pass laterally into greywackes and calcareous conglomerates, occasionally rich in fossils (Dunterclough Beds), and often with local unconformities presenting many peculiar features. Similarly, the Glenkiln graptolitic shales and cherty beds pass laterally into massive grits, greywackes, and shales some 1,200 feet in vertical extent.

From underneath the Glenkiln Beds rises again and again the

sheet of Radiolarian chert, which varies but little in thickness, 60 to 70 feet from end to end of the country. From beneath this chert sheet emerges in its turn a basement volcanic series of pillow lavas, volcanic agglomerates and tuffs, with some Arenig graptolites and other fossils in their highest zone, and answering to the volcanic series of Ballantrae.

This Northern maze thus satisfactorily unravelled, the Survey officers enter next upon the description of the Girvan district, which is supposed to commence at the great Glen App fault. They give a most interesting account of the coast sections between Glen App and Ballantrae, where at the localities of Portandea, Currarie, and Downan, they have discovered the complete sequence from the Arenig (Ballantrae) volcanic rocks, through Radiolarian chert bands into mudstones and greywackes (Tappin's group), with a typical Glenkiln fauna.

The descriptions of these important localities are illustrated by several beautiful photographs by Mr. R. Lunn, showing the 'pillow'-form masses of lava, with their remarkable vesicular structures, and with beds of limestone and Radiolarian chert filling spaces between the pillow-like forms.

The authors next plunge into the Ballantrae volcanic and plutonic complex north of Stinchar Valley. The key section of Bennane Head is first described; the relationship of its Arenig graptolitic (or *Tetragraptus*) bands to the underlying volcanic series and the overlying Radiolarian chert bands is clearly demonstrated, and is illustrated by capital sketch-maps, sections, and photographs. From this key locality the beds of the complex are traced stage by stage along the whole Ballantrae coastline to Kennedy's Pass. The authors show how accurate were Professor Bonney's original conclusions as to the volcanic nature of many of these strata, and the similarity of the associated intrusives with those of the Lizard district. They establish in a general way the sequence of the entire succession of the Ballantrae rocks both along the shore and on land, as at Cragneil and Craighead, and they cite several new localities for Arenig graptolites in the series older than the zone discovered by myself at Bennane Head. Finally, they prove conclusively that the whole of this Ballantrae complex (some of whose plutonic members were erroneously regarded by myself and others to be of post-Girvan age), volcanic and plutonic rocks alike, is of more ancient date than the basal beds of the Barr series, which actually rest upon the volcanic platform, and contain abundant rounded pebbles or fragments of nearly all its known rock-varieties.

In Chapters XXI and XXII we have a summary of the stratigraphy and palæontology of the overlying Girvan formations. The classification and sequence of the various members of the succession, as worked out in my Girvan paper, are again shown to be the natural ones, and the various graptolite zones which enable us to parallel the beds with the Moffat and Upland succession generally are carefully checked and discussed. The Balclatchie beds are, however, now transferred to the base of the Ardmillan Series, and the Blair and

Straiton Beds are definitely assigned to the Wenlock. Long lists of fossils are given both of those collected by the Survey and by others. It is pleasant to note how freely the Survey officers have availed themselves of the fossil lists prepared for them by Mrs. Robert Gray from her magnificent Girvan collection, and how frankly and generously they refer to the value of her work. It is not too much to say that this Gray Collection has proved most important in aiding in the working out of the complexities of the Girvan-Ballantrae district, and in correlating its component formations, not only in the hands of the Survey officers, but in those of their predecessors. How enthusiastically, and yet at the same time how carefully, that collection was made, I can speak from personal knowledge. I look back to many a delightful day spent in the field in the company of Mr. and Mrs. Gray and their family, and I noted the extreme care with which every fresh specimen collected was at once labelled and packed away, so that there should be no future dispute as to the exact spot and horizon where it was obtained.

Chapter XXIII is devoted to a description of the Southern Belt, where the Wenlock-Ludlow (Riccarton) sediments follow conformably upon the Hawick Beds (Tarannon), and range along the south-east flanks of the Borderland. It is shown that the lowest of the recognizable zones here met with is that of *Cyrtograptus Murchisoni*, which the Survey collectors have now traced at or near the base of the series, almost from Jedburgh to the shores of Wigton Bay.

Chapters XXIV and XXV, which deal with the Lanarkshire inliers and those of the Pentland Hills, are fertile in new stratigraphical and palæontological discoveries and in improvements in classification. A novel assemblage of fishes (comprising five genera, four of which and seven species are new), detected in these beds by Mr. M'Connochie during the progress of the revision, is remarkable in many ways. According to Dr. Traquair, "zoologically the interest of these fishes is extreme, and this fauna has opened out to us a new vista in the field of Palæozoic ichthyology." With these fishes are associated representatives of all the genera of Eurypteridæ found in the Ludlow rocks. All these fossils occur in a series of red and yellow sandstones, red and green mudstones and conglomerates, some 2000–3000 feet in thickness, which graduate upwards conformably from the grey Wenlock-Ludlow Series of Lanarkshire and Pentland Hills, but have hitherto been classed as the basal member of the Old Red Sandstone. But the peculiar features of these fossils, however, as now ascertained, ally this rock group rather with the Passage Beds strata (Downtonian), which in Shropshire and elsewhere intervene between the Aymestry Limestone and the base of the Herefordshire Old Red Sandstone. This circumstance, together with the fact that this rock group underlies the more typical members of the Scottish Old Red Sandstone unconformably, has prompted the officers of the Survey to regard the whole of it as of Downtonian age, and as

forming the terminal member of the Scottish Silurian. On this view first advocated by Messrs. Brown and Henderson several years ago, many controversial difficulties disappear, the views of local amateurs and the views of the Survey are harmonized, and the Scottish Silurian brought into closer parallelism with the Silurian of Southern Britain and elsewhere.

In Chapter XXVI Mr. Teall furnishes us with a masterly summary of his petrological researches into the characters and constitution of the Galloway granites and their associated rocks, founded mainly upon materials collected during this revision of the Uplands. He shows that the three granitic masses of Criffel, Loch Dee, and the Cairnsmore of Fleet present such resemblances and differences as are best explained by granting that they belong to the same petrological province, and in all likelihood were derived from the same magma basin. In average composition the Criffel mass is the most basic—being a tonalite rather than a true granite; the Cairnsmore mass the most acid—a biotite granite; and the Loch Dee mass intermediate in character—a hornblende granite. But in each mass we find rocks which are more acid and more basic than the average, extreme types being represented by hyperites and muscovite-biotite granites; but between the most extreme types we have a continuous series of intermediate varieties.

The curious resemblances which obtain between these Galloway rocks and similar petrological types of other areas in Britain and abroad, in widely separated districts, and in rocks of different geological age, are pointed out, and the conclusions are drawn that plutonic rocks, like minerals, are subject to paragenesis; and that in Galloway, as elsewhere, the phenomena are in accord rather with the differentiation hypothesis than with that of assimilation.

The petrological reader will follow with keen interest the descriptions of the minuter characters of the rock masses and rock varieties—the veins, the dykes, the foliated rocks, the aureoles of metamorphism and their characteristic phenomena—as given by Mr. Teall in this and the following chapter, and discussed in brief in their relation to each other and to the unsettled problems of petrological science in general.

When we recollect that, in addition to these special chapters, the volume is enriched by numerous petrological descriptions, scattered like the sketch-plans and sections through its pages, we appreciate how important a rôle the science of petrology has now begun to play in the development of the geology of every complicated region. This petrological work is illustrated by several excellent micro-photographs, but it is to be lamented that it is accompanied by so few chemical analyses.

The final chapter in the volume deals with the Economic products of the Upland rocks—the building-stones, the granites, the ornamental stones, the workable ores, etc. We consider this chapter, more especially because of its brevity, as the least satisfactory in the book. The economic geology, as such, is as much the province of the geologist, and demands as respectful a treatment,

as the detailed stratigraphy of a country. Not only are the facts connected with the former especially well known to the Surveyman, but they appeal peculiarly to the business mind of his employer, the Britisher in general. But indeed, as it has been well said, not one of us, if we are scientists at heart, can afford to ignore any branch of our science, "even though it be conspicuously — and even glaringly—useful."

At the end of the work we have an Appendix, containing several carefully prepared tables; a general list of the Upland graptolites collected by the Survey, showing the formations they characterize; a general list of all the Upland fossils of other classes in the Survey collections; a list of fossil species prepared by Mrs. Gray from her fine Girvan collection; comparative tables of fossils from the Stinchar Series, the Balclatchie Beds and their equivalents, etc.; from the Wenlock-Ludlow formations; and finally, a complete bibliography. We have already referred to the many illustrations collected together at the end of the book, but the absence of plates of the characteristic forms of the group of the Radiolaria, which has proved itself of such high import in the formation of perhaps the most remarkable of the Upland rock sheets, is much to be regretted.

We have already pointed out how the field observations in the revision of the Uplands were conjointly the work of Messrs. Peach and Horne, assisted by Mr. M'Connochie as fossil collector. The graptolites were identified mainly by Mr. Peach, the various other fossils were classified and arranged by him, and he also prepared all the illustrative diagrams, sketch-plans, and sections. The exacting task of arranging the materials and of writing almost the whole of this most interesting volume has fallen to the share of Mr. Horne, and the Director General has edited the whole.

The book is alive throughout with interest and enthusiasm, and it is well abreast, if indeed it is not well in advance, of anything yet done in this special department abroad. It is evident that the authors have spared themselves neither time nor trouble to arrive at correct results and conclusions. It affords another proof, if such were needed, that zonal work is probably destined to effect in the history of geological research a revolution as great and an advance as rapid as those brought about by the use of the microscope in the history of biology. This volume does not mark the close of geological investigation in the Uplands. It marks rather its true beginning.

CHAS. LAPWORTH.

II.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY FOR 1898. 8vo; pp. 216. (London: Eyre & Spottiswoode, 1898. Price 1s.)

LAST year, in the GEOLOGICAL MAGAZINE for July and August (pp. 306 and 358), we drew attention to the first issue of this "Summary of Progress," which was prefaced by a full history of the origin of the Geological Survey and Museum of Practical Geology.

The present "Summary" gives a very detailed account of the observations made in the field and in the palæontological and

petrographical departments during the past year. The record is one which indeed reflects credit on the small band of enthusiastic workers which compose the Survey. Their reports have been pieced together by the Director General, who has himself contributed notes on the Dalradian schists and Old Red volcanic rocks near Oban, on the volcanic rocks in the Carboniferous Series of Somerset, and on the older rocks of Skye and Scalpa.

It is hardly possible to do more than glance generally at the contents of this detailed report. The subject-matter is arranged in stratigraphical order, beginning with the Pre-Cambrian rocks of Ross-shire and continuing to the Peat-bogs of Ireland. Something of interest will be found for all students and workers, in the occurrence of minerals and fossils, in the discussions on schists and rock-structures, in the accounts of volcanic and plutonic rocks, of contact metamorphism, faults and foldings, in the descriptions of new railway-cuttings, well-borings, and in the analyses of dolomites and iron-ore.

The accounts of the Pre-Cambrian rocks of Ross-shire contain much that is interesting, while on some points further information is desirable. Mr. Peach divides the rocks into two main groups—(1) the Lewisian gneisses and (2) the Moine type of gneisses and muscovite-biotite-schists. The Lewisian gneiss is supposed to be the older, and is stated (p. 7) to have been "thrust forward among the Moine schists," but there does not seem to be any clear evidence of this, for a little further on he says "there seems to be a definite order in at least the local succession," and the "Moine schists always lie next to the older gneisses, while the centres of the synclines of these schists are occupied by the muscovite-biotite gneiss." This does not give the impression of a "thrust-plane" junction, and, indeed, it is practically stated only a few lines further on that the junction is an unconformity. If this is so, one would expect a pebbly base to the Moines, but no mention of such a base occurs. Neither is there any information as to the age of the crystallization of the two groups of rocks, whether they are of the same age or not. An interesting series of foliated granites is described on p. 9.

Mr. Horne, in the Fannich area, gives an account of several rock-groups that he has been able to map out, which are a continuation of those already mapped by Mr. Gunn. Five of these are mentioned in "what appears to be descending order." The remarkable part of this sequence is that No. 1, or the highest, is stated to "resemble certain types of Lewisian gneiss." The lowest, No. 5, is obviously the same as the lower member of the Moine schist of Mr. Peach. The difficulty with regard to No. 1 is recognized by Mr. Horne, who suggests two explanations of it, the first of which indicates a structure similar to that of the Archæan gneiss of Loch Maree. We may also note (p. 15) that No. 5, the most persistent type of the Moine schists, was probably crystallized "prior to the Post-Cambrian movements."

Mr. T. I. Pocock describes somewhat similar groups, but on p. 17 the following statement is made:—"The basic portions of the

granitoid gneiss usually appear as hornblende-schist dykes, traceable for short distances, and folded with the main mass of the rock. East and west of the main outcrop of flaky gneiss, but folded with it, are masses of quartzose gneiss belonging probably to the Moine-schist series, but placed in this group on account of the presence of hornblende-schist dykes. In many parts the rock is indistinguishable from the typical quartzose Moine-schist, whilst in others the occurrence of thin felspathic folia and 'eyes' associates it with the Acid gneiss." Apparently the grouping of these rocks is made to depend on the presence or absence of hornblende-schist dykes. We would like to know more of these hornblende-schist dykes. Are they of the same age as the Scourie dykes, or what is their age?

Under the term "Dalradian or younger schists of the Highlands" are included the rocks of the Central Highlands. The heading suggests that these rocks are newer than those last described. We should like to know the evidence of these being "newer gneisses." Has any evidence on this point been published? And if so, where?

Mr. Barrow draws attention to the identity in structure and appearance of the rocks of the Braemar area with the Moines described above by Mr. Peach and Mr. Horne, and he traces their connection with the quartzite and limestone series of the Central Highlands. Mr. Cunningham Craig also describes a series of rocks closely resembling the quartzose phase of the Moine schists or gneisses, and he too connects these with the quartzite and limestone series.

In the notes on the "younger granites of the Grampian Hills," the large masses of the Central Grampians and the smaller intrusions of much the same age, are described in detail by Messrs. Barrow, Cunningham Craig, and Hinxman. Messrs. Hinxman and Craig give evidence showing the thermo-metamorphism produced by these granites.

Leaving the Dalradian schists we come to accounts of fossils from the Cambrian rocks of Skye, and to records of fossiliferous Silurian rocks in Ireland. Another new genus and species of fossil fish from the Upper Silurian rocks of Lesmahagow, *Ateleaspis tessellata*, is named by Dr. Traquair. Several good specimens of a new species of *Eurypterus* of the type of *E. scorpoides*, Woodw., were collected from the Downtonian rocks of Ayrshire and Lanarkshire. In Caithness, Ross-shire, and the Lorne much new information was obtained regarding the Old Red Sandstone, while the granites of Ben Cruachan and Glen Etive and the effects of contact metamorphism were attentively studied by Mr. Kynaston, aided by Mr. Teall. To the latter we owe the discovery of corundum among the cordierite-bearing rocks of the contact zone round the Ben Cruachan granite.

The resurvey of the South Wales Coalfield and bordering rocks has been vigorously pursued by Mr. Strahan, Mr. Tiddeman, and Mr. Cantrill, and much new information has been gathered with reference to the structure of the Vale of Neath and of the superficial coverings of Glacial Drift. In Devonshire and Cornwall, Mr. Ussher,

Mr. J. B. Hill, and Mr. S. B. Wilkinson have been busily at work, while in North Staffordshire Mr. Walcot Gibson reports a considerable extension of the Coal-measures under Little Madeley and Craddocks Moss.[1] He notes also his discovery of a new bed of iron-ore in the Fenton Park Clay-pits, and an analysis of the rock is contributed by Dr. Pollard.

Various members of the staff furnish notes on Permian, Trias, Jurassic, and Cretaceous rocks, and they give many particulars of the Glacial drifts. Mr. Harker's observations on the Tertiary igneous rocks of Skye deal largely with the very numerous basaltic sills which have been intruded into the basaltic lavas. These sills are for the most part younger than any of the great plutonic intrusions of basalt or granophyre.

In illustration of the work done on the Glacial Drifts we may refer to the observations made by Mr. G. W. Lamplugh in the neighbourhood of Uttoxeter in North Staffordshire. He remarks that the prevalent Drift of the higher ground is a red sandy loam, or, more rarely, clay, containing numerous rounded quartzite and other pebbles derived from the Bunter (which frequently show the characteristic pittings), together with an occasional partially rounded fragment of hard sandstone probably derived from the Carboniferous rocks. The absence from a great part of the district of stones larger than one foot in diameter, and of any showing clear proof of glacial striation, together with the sandy character and local derivation of the material, seem to render the term 'boulder-clay' somewhat inapplicable to this deposit. Evidence was obtained, however, that in spite of its abnormal composition and general resemblance to 'rain-wash,' the material is the local equivalent of the true Boulder-clay of contiguous tracts, and has had a similar derivation from the moving mass of land-ice by which the whole country has been covered. The clearest proof of this was furnished by the presence of well-glaciated surfaces of Lower Keuper Sandstone at an elevation of 700 feet above O.D. (almost the highest ground in the neighbourhood), which were uncovered towards the end of last year in the large quarries at Hollington. These surfaces were directly overlain by the usual pebbly loam of the district, of rather unusual thickness (from 10 to 25 feet), and the direction of the striæ—W. 20° N. to E. 20° S.—shows that the movement of the ice has not been determined by the shape of the ground in the vicinity nor by the presence of the elevated Carboniferous Limestone tract of the Weaver Hills a few miles to the northward, but has been consequent upon the pressure of the great ice-sheet which was piled up over the lower ground to the westward and north-westward. As this is the only locality in the district where there is any rock sufficiently coherent to exhibit such traces of glaciation, it is fortunate that the quarry-sections should afford such opportune exposures.

Further evidence that the pebbly loam must be regarded as a local variety of the Boulder-clay of the great ice-sheet is afforded

[1] See paper read by Mr. Gibson in Section C., Brit. Assoc. meeting at Dover.

by the fact that on the rising ground south of Uttoxeter, opposite to the great bend in the Dove Valley, where the river swerves from a southerly to an easterly course, the pebbly loam is suddenly replaced by a true till in which large subangular striated boulders of Carboniferous Limestone, toadstone, and other rocks are abundant. This material evidently indicates the path taken by the stream of ice which has descended the valley of the Dove; and Mr. Lamplugh urges that its local development in relation to the more prevalent type of pebbly drift tells strongly in favour of the land-ice as opposed to the marine theory of the origin of these drifts.

Lists of memoirs and maps published and in hand are given at the end of this report, and it is accompanied by small index maps showing the state of progress of the surveys in different parts of the United Kingdom.

III.—The History of the European Fauna. By R. F. Scharff, B.Sc., Ph.D., F.Z.S. 8vo; pp. i–viii, 364, with 21 illustrations. (London: Walter Scott, 1899. Price 6*s*.)

THE present volume is the outcome of a memoir read by the author before the Royal Irish Academy, and originally published in their Proceedings for 1897. Of this communication we gave a lengthened notice in the Geological Magazine, 1897, Dec. IV, Vol. IV, pp. 420, 468.

Dr. Scharff is a naturalist in the true sense of the word, and gathers his illustrations of geographical distribution from plants and insects, crustacea and mollusca, as well as from birds and mammals. Nor are the facts and observations furnished by the geologist bearing upon the interesting problems of which he treats neglected by the author. In his Preface he says: "Our knowledge of the present and past fauna of Europe is as yet insufficient to indicate with precision the original homes of its component elements, but I hope that the lines of research laid down here, and the method of treatment adopted, will aid zoologists and geologists in collecting materials for a more comprehensive study of the history of our animals. I trust also that a fresh impulse will be given by the publication of this book to the study of the geographical distribution of species. Collectors of beetles, butterflies, shells, and fossils may derive some useful hints by its perusal, and thus direct their studies so as to add, by accuracy in observation, to our knowledge of the former geographical revolutions which have moulded our islands and continents. To geographers, a survey of some of the more important changes in the distribution of land and water in past times, based upon the composition of our fauna, will be interesting. The subject, however, is a complex one. I have ventured to indicate a suitable method of treatment, and as such this attempt to elucidate the history of the European fauna should be received." (p. v.)

"Every student of natural history," writes Dr. Scharff (p. 1), "whether he be interested in birds, butterflies, or shells, contributes his share of facts which help to show how the fauna of his country

has originated. The capture of a swallow-tail or of a marbled white butterfly in England at once furnishes material for reflection as to the reason of its absence from Scotland and Ireland. Why should the nightingale allow its beautiful song to be heard in England, and never stray across the Channel to the sister isle or cross the borders of North Britain? Lovers of bird-life and sportsmen, who have observed the habits of the ptarmigan in the wild mountain recesses of Scotland, are aware that nowhere else in the British Islands do we meet with this interesting member of the grouse family, and many no doubt have allowed their minds to dwell upon the causes of its singularly local distribution.

"All these animals have a wide range in other parts of the world. In past times, before man began to make observations on the geographical distribution of birds and butterflies, or even before the appearance of man in Northern Europe, they may have lived all over the British Islands. For some reason or other they are perhaps dying out or withdrawing towards their original home, which may either be northward or to the east or south. If we had some clue as to their former history from fossil evidence—or, in other words, if their remains had been preserved to us in geological deposits—we should have less difficulty in deciding this problem. But butterflies are scarcely ever preserved in a fossil state, and birds very rarely. We know little or nothing, therefore, of their past history from direct evidence, and are obliged to trust to indirect methods of research, which will be indicated later on.

"Mammals and snails tell their story more plainly. The bones of the former and the shells of snails are easily preserved, and thus furnish us with the necessary data as to their past history, for we find them abundantly in most of the recent geological deposits. Among the mammals of the British Islands there are some instances of distribution which much resemble those I have quoted. Thus the Arctic Hare (*Lepus variabilis*) is in the British Islands confined to Ireland and to the mountains of Scotland; and if it were not for the fact that its bones have been discovered in a cave in the south-west of England, we should perhaps never have known that, formerly, it must have inhabited that country as well. Of other mammals we possess fossil and also historical evidence of their having once lived in these Islands, such as the wolf and the wild boar, both of which were abundant in Great Britain and Ireland. The latter is a distinctly southern species. We assume this because its remains have never been found in high northern latitudes; nor does it now occur in Northern Europe or Northern Asia, whilst all its nearest relatives live in sub-tropical or tropical climates. The Arctic Hare, on the contrary, has probably come to us from the north. Its remains are unknown even in Southern Europe, and the more we approach the Arctic regions the more abundant it becomes. Thus we have here two instances of British mammals, one of which, the wild boar, has died out, as it were, in a southerly direction; whilst the other, the Arctic Hare, is apparently retreating towards the north.

"There are also some British mammals of which we have no fossil history, at least of which no remains have as yet been found in these Islands. Such a one is the harvest-mouse (*Mus minutus*). It has a somewhat restricted range in England, and only just crosses the Scottish border in the east. From the rest of Scotland and from the whole of Ireland it is absent. To judge from this distribution, in connection with the fact of its being unknown as a British fossil species, it is probably a late immigrant to England, and has not had time to spread, through Scotland at any rate. But it is also absent from Scandinavia, from the Spanish Peninsula, from almost the whole of Italy and the Alps, as also from the Mediterranean islands, whilst the little mouse occurs abundantly right across Siberia. We shall learn more about centres of dispersion later on; meanwhile I should mention that such a distribution indicates that the harvest-mouse has most likely originated in the east, and has spread from there westward in recent geological times.

"Conchologists have long ago been acquainted with the fact that many molluscs, for example the so-called 'Stone-cutter' Snail (*Helix lapicida*) and the 'Cheese Snail' (*Helix obvoluta*), have a very restricted range in the British Islands. Both are entirely absent from Scotland and Ireland, the Cheese Snail being confined to South-Eastern England. The Stone-cutter has rather a wider range, is even known from a Welsh locality, and is met with as far north as Yorkshire. Their distribution would indicate, therefore, that while both are recent immigrants the Cheese Snail is probably the last comer. This supposition is in so far supported by fossil evidence, as the latter is unknown in a fossil state, whilst the Stone-cutter has been described by Messrs. Kennard & Woodward as occurring in the cave deposit known as Ightham-fissure, and also from several English Pleistocene and Holocene deposits. The Stone-cutter can scarcely be looked upon as a very recent immigrant in the light of this evidence, though we have no proof of its having ever had a much wider range in the British Islands than it has to-day.

"Among the lichens, which so abundantly cover the rocks and trees in South-Western Ireland, and which impart such a characteristic feature to the scenery, we find a beautifully spotted slug (*Geomaculus maculosus*). It is a stranger to the rest of the British Islands, and, indeed, occurs nowhere else in Northern Europe. We have to travel as far as Northern Portugal before we again meet with it; it is there also that its nearest relations live.

"Many more similar examples might be quoted, but enough, I think, has been said to show that the British fauna is made up of several elements whose original homes may be widely apart and in different directions. We have fossil evidence that some of the Northern species, and also a few of the southern ones, have become extinct within comparatively recent times, others are apparently on the verge of extinction, whilst many not only maintain their position in the constant struggle for existence, but are even extending their range." (p. 5.)

We are glad that Dr. Scharff has given us his views on the history

of the European fauna in the form of a little book, as it was not so easy for the student to obtain access to the original paper in the Royal Irish Academy's Proceedings. The illustrations add greatly to the interest of the volume, but they might well have been more numerous. We are sure it is a book which will have many readers and some few critics. We have already made some criticisms on the original paper,[1] and will now only commend it to our readers in its present form as a most attractive little volume on a most fascinating subject by a very able and clever Naturalist.

CORRESPONDENCE.

THE LIMESTONE KNOLLS OF THE CRAVEN DISTRICT.

SIR,—In a recent suggestive paper on the Limestone Knolls of the Craven District (Q. J. G. S., vol. lv, 1899, pp. 327–358), Mr. Marr's criticisms of my views on the Keisley Limestone appear to demand some reply, as unfortunately I was not present when his paper was read. I do not intend to examine the plausibility of Mr. Marr's views of the origin of the Craven knolls, with which I have only a slight acquaintance in the field, though, as I have paid some attention to their fossils, I may remark in passing that he does not bring forward the least palæontological evidence in support of his conclusions. It is the neglect or lack of appreciation of the palæontological evidence furnished by the Keisley Limestone by which he escapes the difficulties in which he would otherwise be there involved. For it is not here a case, as Mr. Marr appears to think (op. cit., p. 356), of the relative abundance of fossils, but of an assemblage of fossils with a facies entirely distinct from that of the neighbouring strata. When Mr. Marr can prove that the fauna of the thin white limestone which apparently represents stratigraphically the Keisley Limestone is identical with the fauna of the latter, his conclusions will rest on a firmer basis. Moreover, in order to demonstrate that the theory of discontinuous distribution is untenable, Mr. Marr must be able to prove the general distribution of the peculiar Keisley Limestone fauna over the intervening areas; otherwise he must acknowledge that some special local biological or physical conditions contributed to the congregation of this fauna in isolated colonies. Modern instances of discontinuous distribution with stations of limited superficial area admittedly offer problems hard to solve, but we cannot shut our eyes to their existence; and there is no *a priori* reason why similar instances should not be discovered in the records of the past, though naturally the difficulties of fully explaining them would be increased in dealing with extinct species.

It is needless here to recapitulate my reasons for drawing my conclusions as to the nature of the Keisley Limestone fauna; some of the less important ones are quoted and discussed by Mr. Marr, but the more important detailed palæontological evidence which he omits can be studied in my papers (Q.J.G.S., vol. lii, 1896,

[1] See GEOL. MAG., 1897, pp. 420 and 468.